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National Aeronautics and
Space Administration

Budget Estimates

Fiscal Year 1995

Volume I

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1995 BUDGET ESTIMATES

GENERAL STATEMENT

The National Aeronautics and Space Administration (NASA) leads the United States' preeminent programs in aeronautics, space exploration and flight activities for peaceful purposes. Its unique mission of exploration, discovery and innovation has preserved the United States role as both a leader in world aviation and as the preeminent spacefaring nation.

The NASA budget request of $14,300 million has been restructured in FY 1995 into four appropriations:

Human Space Flight - providing funding for the Space Station and Space Shuttle programs, including flight support for cooperative programs with Russia;

Science, Aeronautics and Technology - providing funding for NASA's research and development activities, including all science activities, global monitoring, aeronautics, technology investments, education programs, mission communication services and direct program support;

Mission Support - providing funding for NASA's civil service workforce, space communication services, safety and quality assurance activities, and maintenance activities for the NASA institution.

Inspector General - providing funding for the manpower and support required to perform audits and evaluations of NASA's programs and operations.

This budget request reflects the President's strong commitment to space and aeronautics. It also signals a continuing commitment by NASA to conduct its activities in the most efficient and effective manner, to be aggressive in pushing the entire community involved in NASA's programs to gain the maximum value from every dollar spent. NASA was actively involved in the National Performance Review (NPR), and is proceeding to implement the recommendations of the NPR, both as they relate specifically to NASA and to the federal government in general. A strengthened program management system has been implemented which will focus senior management attention on program performance. The FY 1995 budget request signals a new way of doing business in all aspects of NASA's program planning and execution.

The FY 1995 budget request concentrates on:

- Implementing a fundamentally expanded program of human cooperation in space, combining the efforts of Europe, Japan, Canada, Russia, and the United States in a broad range of human space activities;

- Continuing the nation's premier program of space exploration, to expand our knowledge of the solar system and the universe as well as the Earth, and understand the nature of global environmental problems; and,

- Investing in the development of new technologies, particularly in aeronautics, to strengthen the leadership position of the United States as an innovator and to ensure the future competitiveness of the Nation.

This budget has been formulated with the imperative of conserving the financial resources of the Nation by making difficult decisions concerning the priorities of the Nation's space and aeronautics program. The resulting budget supports a program which will encourage innovation, return valuable scientific results, strengthen the research capabilities of the nation, and benefit the United States taxpayers and also demand strict accountability for results. The five year budget plan for NASA requires continuing, significant reductions in the cost of executing programs and supporting activities funded within all appropriations. NASA is committed to reducing program overhead and eliminating activities with only marginal benefit. Savings generated by these actions will be applied to enable a more robust NASA program.

The NASA budget has been restructured to consolidate funding for human space flight activities, for science, aeronautics and technology activities, and for the basic support of NASA programs into separate appropriations. This new budget structure will provide a focused discussion of space activities, and provide a framework for policymakers to emphasize program priorities.

HUMAN SPACE FLIGHT

This new appropriation encompasses all the human space flight activities, including development of the Space Station and the safe and efficient operation of the Space Shuttle. An intensive redesign of the Space Station was conducted in 1993. During that review, the possibility of including Russia as a partner in the program was examined. The partners of the international Space Station, led by the United States, extended an invitation to Russia to join them in the development of the space-based, orbiting laboratory, and an unprecedented agreement was reached with Russia to become a partner in the effort to produce an international Space Station. Russia brings extensive experience in long-term space habitation, which includes expertise on the effects of long-duration space flight on humans and experience in the design and operation of space stations. The opportunity to conduct cooperative missions of several months on the Russian Mir Space Station will provide valuable experience and test data which will greatly reduce the risks associated with the construction and operation of the international Space Station. The participation of Russia in the Space Station program will advance the space programs of both the United States and Russia and benefit the aerospace industries of both countries.

The transition to the redesigned Space Station program is being completed. A new management structure has been put in place which establishes a clear line of management responsibility and accountability. The new design maximizes the use of the previous Space Station Freedom design, and preserves the modular approach to development and assembly. The civil service workforce supporting the program is being reduced, reflecting the reduction in management layers incorporated into the program management structure. A Systems Design Review on the redesigned Space Station is scheduled for March 1994. An integrated schedule, incorporating the development of the United States and Russian hardware elements, is being finalized which will result in a total assembly schedule for the program. The Russian contributions to the program will include transportation services, a service module, a "tug module" for early station attitude control and reboost, and a crew rescue vehicle for rescue and crew rotation. The contributions of the Japanese, European and Canadian partners remain the same as previously planned.

Funding is included to implement an expanded program of cooperative efforts with the Russians which encompass early use of the Space Shuttle and Russian Mir Space Station. In October 1992, the United States and Russia agreed to cooperate in a limited number of joint space flight activities involving exchange of visits by United States astronauts and Russian cosmonauts to the Mir and on the Space Shuttle. In December, 1993, the United States and Russia expanded the scope of this agreement to include four or more U.S. astronaut flights on the Mir station for a total on-orbit stay time of approximately 24 months and up to ten Shuttle flights to Mir between 1995 and 1997. Funding is included to support the mission planning, development of the experiment hardware, and procurement of the Shuttle hardware to enable docking of the Space Shuttle to the Mir station. Funding is also included for a fixed-price contract with the Russian Space Agency for $100 million for each fiscal year, between FY 1994 and FY 1997. This contract will provide for delivery of hardware elements and services in support of the U.S.-Russian cooperative activities, which are currently being defined.

The Space Shuttle continues to provide several unique capabilities to the United States space program. In 1993, seven missions were conducted, including the highly-successful repair of the Hubble Space Telescope. That mission included a record number of hours of extravehicular activity, which will also prove highly beneficial in planning future spacecraft repair missions and assembly of the Space Station. Eight Shuttle missions are planned for each of FY 1994 and FY 1995, and will feature Spacelab flights focusing on Materials Science, Astrophysics, Earth Sciences and Life Sciences.

The Space Shuttle program continues to aggressively search for ways to reduce costs without sacrificing safety. Contractor manpower levels supporting the preparation of payloads, mission planning, and hardware processing activities will be reduced. The program also incorporates a revised role and responsibilities for NASA civil servants, with less reliance on support contractors in given areas where it is appropriate for NASA civil servants to move into a "hands-on" role. Funds are included to continue the implementation of high-priority safety and performance upgrades to the Shuttle initiated in previous years. Spacelab flights will continue through 1997. Beginning in FY 1995, future Spacelab-type missions will be transitioning for

deployment on the redesigned Space Station. As a result of the Russian cooperative program and the opportunities for long duration flights on Mir, there is a greatly reduced justification for the Space Shuttle/Spacelab stand-alone long-duration capability. Accordingly, NASA is proposing the termination of the Long Duration Orbiter development.

SCIENCE, AERONAUTICS AND TECHNOLOGY

Space Science

The Space Science program is designed to expand our scientific understanding as we move away from the Planet Earth. This ranges from understanding the origin and evolution of the universe, to the nature and evolution of galaxies, stars and planets, to the makeup and dynamics of the different layers of space plasmas which make up 99 percent of the universe. Each program conducts development, operation and research activities in their respective science disciplines.

Development activities continue on the Advanced X-ray Astrophysics (AXAF) and Cassini missions. In 1992, the AXAF mission was restructured into two smaller missions: AXAF-I, which focused on high resolution imaging and dispersive spectroscopy, and the AXAF-S which focused on high spectral resolution spectroscopy. AXAF-I is proceeding on its development schedule, with launch on the Shuttle scheduled for FY 1998. The Congress directed in the FY 1994 HUD-VA-Independent Agencies Appropriations Act (P.L. 103-124) that activity on AXAF-S be terminated, and to pursue flight of the X-Ray Spectrometer (XRS) instrument aboard the Japanese Astro-E mission. Due to the lack of detailed definition or the U.S. involvement, a specific funding request has not been made in this budget The funding provided for this purpose in the FY 1994 appropriation is being applied to study instrument modifications and spacecraft interfaces. The joint. U.S.-Japan studies include assessments of scientific merit, amount of U.S. funding required, and development schedules. If, upon completion of these studies, the joint program is determined to be scientifically meritorious and programmatically feasible, NASA will provide the results to the Congress and propose appropriate changes to the FY 1995 budget request.

The Cassini mission will continue the United States' leadership position in planetary exploration by conducting extensive investigations of Saturn, its rings, and its satellites. In an effort to reduce total program costs and improve mass and schedule margins, the program was restructured in 1992. Despite significant changes to the spacecraft design, the science payload remains essentially intact. Development activities are currently underway with the launch scheduled for October 1997 aboard a Titan IV launch vehicle. The Magellan spacecraft has mapped approximately 99 percent of the surface of the planet Venus to a ground resolution of about 150 meters. The spacecraft successfully completed an aerobraking experiment to circularize its orbit in the summer of 1993, and is currently collecting high resolution gravity data from this new orbit. Extensive data processing and analysis of existing radar data sets are underway as well. Mission operations are planned for termination by the end of FY 1994. The planet Mars has been a primary

program focus due to its potential for previous biological activity and for comparative studies with Earth. The Mars Observer mission was launched in September 1992 and arrived at Mars in August 1993. Unfortunately, communications with the spacecraft were lost just prior to orbit insertion. Funds are included to initiate the Mars Surveyor program, a series of small missions designed to resume the detailed exploration of Mars.

Funding is also included to continue development of two missions initiated in FY 1994, the Mars Environmental Survey (MESUR) Pathfinder and the Near Earth Asteroid Rendezvous (NEAR) missions. These missions are the first two Discovery missions that will demonstrate the viability of low-cost, quick design-to-flight planetary missions. A Discovery mission development cost (phase C/D through launch plus 30 days) must be within $150 million (FY 1992 $) and must launch within three years from start of development. MESUR Pathfinder will provide information on the atmosphere and surface characteristics of Mars. NEAR will conduct a comprehensive study of the near Earth asteroid 433 EROS. Both missions are planned for launch on Delta II expendable launch vehicles. MESUR Pathfinder is scheduled for launch in December 1996; NEAR is scheduled for launch in February 1996.

Funding is also included to continue development of the Relativity Mission, which combines two previously separate programs, the Gravity Probe-B mission and the Shuttle Test of Relativity Experiment. The Global Geospace Science spacecraft, Wind and Polar, are scheduled for launch in FY 1994. Current indications are that the launch of Polar, and possibly Wind, could slip into FY 1995. Upon completion of this assessment, the agency will determine what additional funding is required in FY 1994 and FY 1995. The Explorer program continues to support the X-ray Timing Experiment and the Submillimeter Wave Astronomy Satellite, both scheduled for launch in 1995. Development of the Advanced Composition Explorer was initiated in FY 1994 in preparation for launch in 1997.

The Hubble Space Telescope (HST) Servicing Mission in December 1993 restored the capabilities of the HST to the original design specifications, and the HST is now able to see ten times farther than before the optical correction was made. This has increased the field of objects available for study by 1,000 times. Mission Operations funding will support the science investigation teams for HST and the preparations for future HST servicing missions planned for 1997 and 1999. Mission Operations and Data Analysis (MO&DA) funding will also support development of unique ground systems elements of the AXAF program, final preparations for Galileo's arrival at Jupiter in December 1995, and continued data and analysis activities for the Compton Gamma Ray Observatory mission, the Extreme Ultraviolet Explorer mission and other missions. The Research and Analysis (R&A) program provides ongoing support for basic and applied research, new technology development and theory-building at NASA centers, universities, industrial laboratories, and other government laboratories. Advanced studies will also continue to define technical and scientific requirements for future space science missions.

Funding for science data management, archiving and science networking are also provided for under the Space Science program. Due to Agency budget constraints, the FY 1995 budget request in several of these areas has

been held to the FY 1994 level, i.e., without provision for inflation, and in other areas has been reduced below the FY 1994 level. Some activities will be reduced or possibly terminated. An assessment of overall program requirements is currently underway to assess priorities and determine candidates for reduction or termination.

Life and Microgravity Sciences

Funding is included for continuing research activities in understanding the response of biological mechanisms and materials science to weightlessness, and the development of experiment hardware for use on the Space Shuttle and Space Station. In Life Sciences, definition and development of experiments and hardware for the Spacelab Life Sciences (SLS) series and other international flight opportunities will continue, including the design and development of payloads for the joint program with Russia which focus on understanding biomedical problems associated with long-duration missions and other microgravity and biotechnology research. A main theme in the research conducted in Life Sciences is the use of gravity as an experimental variable to define the responses of biological systems to a micro- or zero-gravity environment. Funding for the development and utilization of Space Station-based experiment facilities is included in this budget. Continued emphasis is placed on cooperation with the National Institutes of Health (NIH) in biomedical research programs. Specific research initiatives are under development to expand participation of the mainstream biomedical community in the NASA Life Sciences program.

Funding for Microgravity research will continue basic and applied research activities as well as the payload development effort, using Shuttle middeck, Spacelab, Mir, and cargo-bay experiments. A series of future flights is planned over the next several years which will provide opportunities for evolving microgravity experiments from short- to long-duration periods of on-orbit operations. Preparation for the advent of Space Station operations will intensify in FY 1995, with substantial work planned for the initiation of payload facility development, integration, training and operations activities.

Mission to Planet Earth

NASA is a major participant in the U.S. Global Change Research program. The Earth Observing System (EOS) program and Earth probes are major elements of this program, and will contribute an understanding of the global climate system. The EOS will provide long-term data sets for use in modeling and understanding global processes, and the first EOS satellite, AM-1, is scheduled for launch in mid-1998. The Earth probes will provide data in specialized areas, such as tropical rainfall, ocean wind speed and direction, and global ozone concentrations. There are three Earth Probes currently under development. The Tropical Rainfall Measurement Mission (TRMM) spacecraft is scheduled for launch in 1997 by a Japanese launch vehicle. The NASA Scatterometer (NSCAT) is scheduled for launch on the Japanese Advanced Earth Observing System (ADEOS) Satellite in 1996. The Total Ozone Mapping Spectrometer (TOMS)Scatterometer program includes a set of instruments which will be flown in 1994, 1996 (also on the ADEOS satellite) and will be available for a

flight opportunity in 1998. The EOS Data Information System (EOSDIS) will provide the processing, storage, and distribution of the EOS science data and resulting scientific products. Development of the EOS, EOSDIS and Earth Probes is a high priority of NASA, and funding is included to support the first EOS spacecraft, AM-1, the Earth Probes under development, and the EOSDIS. The budget estimates assume some delay in the EOS-PM and Chemistry spacecraft development schedules. In part, this reflects the delay in the procurement schedule for the common spacecraft bus. The EOS-PM and related spacecraft bus detailed definition phase was extended to permit further consideration of spacecraft configurations compatible with a medium-class expendable launch vehicle. If this approach is determined to be technically feasible and consistent with EOS program requirements, it could result in reduced funding estimates for for launch vehicles and a revised cost and schedule plan. The current program schedules and funding plans assume a larger spacecraft platform and commensurately sized ELV. Also included is funding for development of the first Space Station attached payload in Mission to Planet Earth, the Stratospheric Aerosol and Gas Experiment III (SAGE-III). Consistent with the new budget structure, the budget request for the Science, Aeronautics and Technology appropriation includes funding to continue construction of the Earth Systems Science Building, which will house civil service, contractor, and visiting science personnel conducting global change and Earth science research using EOS.

Consistent with fiscal constraints, the budget provides for the highest priority operation, data analysis and supporting research activities of the Mission to Planet Earth program. The budget also provides for continued land remote sensing program activities, with a revised approach to the Landsat program under consideration.

Aeronautical Research and Technology

The Aeronautics Research and Technology program provides a broad foundation of advanced technology to . strengthen the United States leadership in aviation, an industry which plays a vital role in the economic strength, transportation infrastructure and national defense of the United States. NASA's unique research capabilities contribute to the strengthening of America's aviation industry in many ways, and the FY 1995 program continues important investments required to pursue the high leverage technologies required to support both the subsonic and high-speed civil transport economic viability. These investments are essential to the technology to ensure U.S. leadership for a future high-speed civil transport and to address the important capability and capacity issues associated with future subsonic transport aircraft. Funding is also included to continue NASA's leadership role in the multi-agency High Performance Computing and Communications (HPCC) program. The NASA HPCC program is focused to enable broad advances in aerospace vehicle design, Earth and space systems science research, access to databases of remote sensing images and K-12 science education. Funding for Hypersonics Research has been transferred from the Research and Technology Base and consolidated in the Systems Technology Program budget to focus the program on development of the key enabling technologies for hypersonic air-breathing aircraft. Funding appropriated in FY 1994 for the National Aerospace Plane is not included in this program. Funding for the program support

activities of the Research and Technology Base has been reduced to meet overall Agency budget levels; however, the budget request still supports a strong and challenging fundamental foundation for future aviation advances. Most of the FY 1994 funds for wind tunnel facilities will be made available in FY 1995 for the definition of requirements and design, in collaboration with industry, of new or drastically modified wind tunnels.

Advanced Concepts and Technology

The implementation of the new Office of Advanced Concepts and Technology (OACT) is complete, and the programs of the Space Research and Technology budget and the Commercial Programs budget have been merged. This new office will lead NASA's efforts to support the development and application of technologies critical to the economic, scientific, and technological competitiveness of the U.S. and to promote U.S. industrial preeminence through strengthened linkages between the private sector and NASA technology efforts. The Advanced Concepts and Technology budget is organized around areas of customer focus: advanced space transportation, spacecraft and remote sensing, space communications, space processing, technology transfer, and flight programs. The technology programs which support each of these areas include a range of technology efforts from near-to mid- to longer-term durations. Each program also involves balanced participation by NASA field centers, universities, and industry, including the Centers for the Commercial Development of Space.

The budget request for OACT in FY 1995 will support continued efforts to aggressively pursue the transfer of technology from NASA to the private sector. Funding is included to continue two programs initiated in FY 1994 as part of the President's New Technology Investments. The Advanced Small Satellite Technology program is focused on efforts to develop and apply advanced miniaturization technology for small spacecraft. This program is conducted in partnership with industry, universities, and other government agencies, with a significant focus on proactive technology transfer. The second initiative, the Industry Technology Program, will support technology development and application projects which support high-risk and high pay-off opportunities that demonstrate strong potential for commercial benefits.

Funding for Advanced Space Transportation includes efforts previously distributed in several programs, including the Solid Propulsion Integrity Program (SPIP), the Advanced Launch Technology effort and the Advanced Programs. The Administration is presently conducting an interagency review of the National Space Launch policy to determine a future course of action for supporting near-, mid-, and long-term space launch requirements. This review will be conducted during the first half of 1994. The NASA program plan and budget for Advanced Space Transportation research and technology development activities will be altered consistent with the policy determinations of the Administration and will be submitted to the Congress in accordance with established procedures.

Academic Programs

Science and mathematics achievement is an integral element of the National Education Goals, and NASA's Academic Program strongly support making U.S. students first in the world in science and mathematics achievement by the year 2000. NASA's programs at the pre-college, college, and graduate levels are designed to capture and channel student interest in science, engineering, mathematics and technology as well as enhance teacher knowledge and skills related to these subjects. NASA is actively involved in the activities of the National Science and Technology Council/Committee on Education and Training (CET). This budget request supports the milestones outlined in the CET Strategic plan.

NASA has made a major commitment to playing a leadership role in strengthening the capabilities of minority universities to compete for "mainstream" federal research funding. The FY 1995 budget request for the Minority University Research and Education program will enable NASA to significantly increase its efforts to strengthen the research infrastructure of the Historically Black Colleges and Universities and Other Minority Universities, particularly Hispanic-Serving Institutions.

Mission Communication Services

Beginning in FY 1995, NASA's communications program will be split between in the Science, Aeronautics and Technology and the Mission Support appropriations. Support which is most directly related to NASA's science and aeronautics programs, including ground network support, mission planning for robotics spacecraft programs, suborbital mission support, and support to aeronautics test programs, is included in the Science, Aeronautics and Technology appropriation. Funds are included in this budget to operate and sustain NASA's Deep Space Network, Wallops Flight Facility (and subsidiary facilities), and the Western Aeronautical Test Range which provide support for NASA's robotic science, aeronautics and suborbital programs; and the Spaceflight Tracking and Data Network.

MISSION SUPPORT

Safety, Reliability and Quality Assurance

NASA is committed to providing leadership in quality management of science and engineering programs. The Office of Safety and Mission Assurance (OS&MA) is responsible for the development and implementation of risk management practices and Safety, Reliability and Quality Assurance (SR&QA) practices into all NASA activities. The funding requested in FY 1995 will continue a wide range of activities underway through which SR&QA practices are integrated into the earliest phases of development for space and aeronautics programs. The OS&MA will continue to focus on the Agency's complex software requirements, as it begins operation of the Independent Verification and Validation (IV&V) Facility in West Virginia. This facility will provide leadership in the research and development of software IV&V techniques and standards.

Space Communication Services

Consistent with the new appropriations structure, funding for the operation, sustainment, and replenishment of NASA's Space Network is now funded in NASA's Mission Support appropriation. This program supports the operation of the Tracking and Data Relay Satellite System, the ground terminals at White Sands, New Mexico, and the NASA Control Center at Goddard Space Flight Center. Funds for services provided to non-science users of the TDRSS are included under this program. The NASA Communications (NASCOM) system and the Program Support Communications Network (PSCN) are also funded by this appropriation. Completion of the F-7 spacecraft, and the initiation of procurement activities for the Replenishment TDRS spacecraft (F-8 through F-10) are expected to occur in FY 1994. FY 1995 funding provides for start of the development contract for the Replenishment TDRS spacecraft in FY 1995. The Second TDRS ground terminal is scheduled to begin operations in Spring 1994. Funding is included to continue the upgrade of the White Sands Ground Terminal, which is scheduled for completion in 1995.

Research and Program Management

The NASA workforce is the foundation underpinning the successful achievement of NASA's goals. Funding for the salaries, travel support and other personnel expenses for the entire NASA workforce is included. Consistent with the new appropriations structure, funding for support activities to the NASA workforce and physical plant identified as Research Operations Support has been transferred into the Mission Support appropriation and included in Research and Program Management (R&PM).

Legislation is proposed in the President's Budget Request to cover a shortfall in the R&PM appropriation caused by the implementation of locality pay and by the delay in enactment of buyout authority. The rescission of $95.0 million appropriated in FY 1994 to Research and Development/Space Flight, Control and Data Communications is proposed to enable a supplemental appropriation for FY 1994 of $60 million in R&PM. This supplemental appropriation is required to avoid the extended furlough of the entire NASA workforce. Rescission of the greater amount of funds from the Research and Development and the Space Flight, Control and Data Communications appropriations is required to keep the supplemental action outlay neutral.

Construction of Facilities

Funding is included for discrete projects to repair and modernize the basic infrastructure and institutional facilities, the minor repair, rehabilitation and modification of existing facilities, minor new consruction projects, environemtnal compliance and restoration activities, the design of facilities projects, and the advanced planning related to future facilities needs. Funding for the construction of programmatic facilities has been moved to the appropriate program budgets, consistent with the new appropriations structure.

NATIONAL AERONAUTICS & SPACE ADMINISTRATION

FY 1995 BUDGET SUMMARY
(IN MILLIONS OF REAL YEAR DOLLARS)

	BUDGET PLAN		
	1993	1994	1995
HUMAN SPACE FLIGHT	**6,672.0**	**6,069.7**	**5,719.9**
SPACE STATION	2,162.0	1,937.0	1,889.6
RUSSIAN COOPERATION	79.5	170.8	150.1
SPACE SHUTTLE	3,988.2	3,549.3	3,324.0
PAYLOAD AND UTILIZATION OPERATIONS	442.3	412.6	356.2
SCIENCE, AERONAUTICS AND TECHNOLOGY	**4,908.7**	**5,847.3**	**5,901.2**
SPACE SCIENCE	1,510.4	1,721.9	1,766.0
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS	407.5	515.3	470.9
MISSION TO PLANET EARTH	936.3	1,024.5	1,238.1
AERONAUTICAL RESEARCH AND TECHNOLOGY	769.4	1,102.2	898.5
ADVANCED CONCEPTS AND TECHNOLOGY	464.9	495.3	608.4
LAUNCH SERVICES	180.8	313.5	340.9
MISSION COMMUNICATION SERVICES	546.5	589.1	481.2
ACADEMIC PROGRAMS	92.9	85.5	97.2
MISSION SUPPORT	**2,727.2**	**2,619.0**	**2,662.9**
SAFETY, RELIABILITY AND QUALITY ASSURANCE	32.7	34.3	38.7
SPACE COMMUNICATION SERVICES	333.7	214.4	268.9
RESEARCH AND PROGRAM MANAGEMENT	2,171.4	2,148.2	2,220.3
CONSTRUCTION OF FACILITIES	189.4	222.1	135.0
INSPECTOR GENERAL	**14.6**	**15.4**	**16.0**
TOTAL BUDGET AUTHORITY	**14,322.5**	**14,551.4**	**14,300.0**
TOTAL OUTLAYS	**14,304.3**	**14,201.0**	**14,459.0**

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1995 ESTIMATES

SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS
(Thousands of Dollars)

	TOTAL	R&D	SFC&DC	COF	R&PM	IG
FISCAL YEAR 1993						
APPROPRIATION P.L. 102-398/BUDGET PLAN	14,330,376	7,089,300	5,086,000	525,000	1,615,014	15,062
APPROPRIATION TRANSFER P.L. 103-50	---	5,000		-5,000		
RESCISSION/SUPPLEMENTAL PURSUANT TO P.L. 103-50	-7,200		-27,200		20,000	
LAPSE OF FY 1993 UNOBLIGATED FUNDS	-649				-178	-471
TOTAL BUDGET PLAN	**14,322,527**	**7,094,300**	**5,058,800**	**520,000**	**1,634,836**	**14,591**
FISCAL YEAR 1994						
APPROPRIATION P.L. 103-124/BUDGET PLAN	14,551,399	7,529,300	4,853,500	517,700	1,635,508	15,391
PROPOSED RESCISSION	[-145,000]	[-88,000]	[-32,000]	[-25,000]		
PROPOSED SUPPLEMENTAL	[60,000]				[60,000]	
TOTAL BUDGET PLAN	**14,551,399**	**7,529,300**	**4,853,500**	**517,700**	**1,635,508**	**15,391**

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1995 ESTIMATES

SUMMARY OF BUDGET PLANS BY INSTALLATION BY APPROPRIATION

(Thousands of Dollars)

	Total			Science, Aeronautics And Technology			Human Space Flight			Mission Support		
	1993	1994	1995	1993	1994	1995	1993	1994	1995	1993	1994	1995
Johnson Space Center	2,847,646	2,144,365	1,999,171	167,812	179,749	188,266	2,329,400	1,608,900	1,454,400	350,434	355,716	356,505
Space Sta Program Office......	0	1,280,046	1,339,707	0	0	0	0	1,254,700	1,313,000	0	25,346	26,707
Kennedy Space Center	1,564,725	1,421,490	1,414,027	37,495	38,976	45,729	1,250,200	1,101,500	1,106,600	277,030	281,014	261,698
Marshall Space Flight Center .	3,104,652	2,775,037	2,655,706	412,920	536,956	548,712	2,316,600	1,843,700	1,729,500	375,132	394,381	377,494
Stennis Space Center..........	85,065	83,229	74,663	8,691	11,109	15,337	41,000	27,400	22,600	35,374	44,720	36,726
Goddard Space Flight Center ..	2,274,186	2,214,876	2,456,920	1,669,133	1,708,094	1,886,378	14,400	8,900	9,800	590,653	497,882	560,742
Jet Propulsion Laboratory	807,176	1,013,096	1,083,595	778,524	991,966	1,059,685	1,500	100	0	27,152	21,030	23,910
Ames Research Center	700,018	707,679	690,317	475,145	484,571	454,418	7,200	5,700	6,100	217,673	217,408	229,799
Langley Research Center	543,598	704,518	690,051	312,313	471,576	456,212	3,400	300	0	227,885	232,642	233,839
Lewis Research Center	1,002,633	921,934	781,891	388,804	568,525	539,075	364,200	110,300	7,000	249,629	243,109	235,816
Headquarters	1,340,126	1,283,453	1,078,997	657,889	855,778	707,388	344,100	108,200	70,900	338,137	319,475	300,709
Proposed Supplemental.........	0	-60,000	0	0	0	0	0	0	0	0	-60,000	0
Undistributed Construction of Facilities:												
Various Locations	14,811	14,285	8,955	0	0	0	0	0	0	14,811	14,285	8,955
Facility Planning and Design	23,300	32,000	10,000	0	0	0	0	0	0	23,300	32,000	10,000
Total Budget Plan	14,307,936	14,536,008	14,284,000	4,908,726	5,847,300	5,901,200	6,672,000	6,069,700	5,719,900	2,727,210	2,619,008	2,662,900
Inspector General.............	14,591	15,391	16,000	---	---	---	---	---	---	---	---	---
Total Agency..................	14,322,527	14,551,399	14,300,000									

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1995 ESTIMATES

The FY 1995 multi-year budget estimate is submitted in accordance with the NASA FY 1989 Authorization Law (P.L. 100-685). The enclosed table contains the budget estimates for FY 1995, along with the Administration's projections for 1996 and 1997. For comparison purposes, FY 1993 and 1994 have been restructured to reflect the new appropriation structure.

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
FY 1995 MULTI-YEAR BUDGET ESTIMATES
(IN MILLIONS OF REAL YEAR DOLLARS)

FY 1995 PRESIDENT'S BUDGET

	1993 PAST YEAR	1994 CURRENT YEAR	1995 BUDGET YEAR	1996 EST	1997 EST
HUMAN SPACE FLIGHT	6,672.0	6,069.7	5,719.9	5,594.6	5,533.6
SPACE STATION	2,162.0	1,937.0	1,889.6	1,833.6	1,782.0
RUSSIAN COOPERATION	79.5	170.8	150.1	129.2	111.8
SPACE SHUTTLE	3,988.2	3,549.3	3,324.0	3,295.7	3,316.5
PAYLOAD AND UTILIZATION OPERATIONS	442.3	412.6	356.2	336.1	323.3
SCIENCE, AERONAUTICS AND TECHNOLOGY	4,908.7	5,847.3	5,901.2	5,978.9	5,996.7
SPACE SCIENCE	1,510.4	1,721.9	1,766.0	1,694.4	1,512.0
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS	407.5	515.3	470.9	527.4	545.6
MISSION TO PLANET EARTH	936.3	1,024.5	1,238.1	1,271.1	1,308.2
AERONAUTICAL RESEARCH AND TECHNOLOGY	769.4	1,102.2	898.5	939.3	1,018.8
ADVANCED CONCEPTS AND TECHNOLOGY	464.9	495.3	608.4	631.3	692.3
LAUNCH SERVICES	180.8	313.5	340.9	317.1	301.9
MISSION COMMUNICATION SERVICES	546.5	589.1	481.2	486.6	499.9
ACADEMIC PROGRAMS	92.9	85.5	97.2	111.7	118.0
MISSION SUPPORT	2,727.2	2,619.0	2,662.9	2,810.0	2,952.7
SAFETY, RELIABILITY AND QUALITY ASSURANCE	32.7	34.3	38.7	38.8	39.0
SPACE COMMUNICATION SERVICES	333.7	214.4	268.9	350.3	449.9
RESEARCH AND PROGRAM MANAGEMENT	2,171.4	2,148.2	2,220.3	2,250.0	2,278.7
CONSTRUCTION OF FACILITIES	189.4	222.1	135.0	170.9	185.1
INSPECTOR GENERAL	14.6	15.4	16.0	16.5	17.0
TOTAL	14,322.5	14,551.4	14,300.0	14,400.0	14,500.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY
(DOLLARS IN MILLIONS)

	FY 1993	FY 1994		
	ACTUAL	AMENDED BUDGET ESTIMATE	CHANGE	CURRENT ESTIMATE
RESEARCH AND DEVELOPMENT	7,094.3	7,690.4	-161.1	7,529.3
SPACE STATION	2,122.5	1,946.0		1,946.0
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	649.2	705.0	-42.4	662.6
SPACE SCIENCE	1,577.5	1,700.0	71.9	1,771.9
LIFE AND MICROGRAVITY SCIENCE	139.5	470.0	6.3	476.3
MISSION TO PLANET EARTH	1,154.0	1,112.9	-44.5	1,068.4
ADVANCED CONCEPTS AND TECHNOLOGY	437.1	521.4	-88.7	432.7
AERONAUTICAL RESEARCH AND TECHNOLOGY	865.6	1,020.7	-13.7	1,007.0
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY	0.0	80.0	-60.0	20.0
SAFETY, RELIABILITY AND QUALITY ASSURANCE	32.7	35.3	-1.0	34.3
ACADEMIC PROGRAMS	92.9	74.5	11.0	85.5
TRACKING AND DATA ADVANCED SYSTEMS	23.3	24.6		24.6
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS	5,058.8	5,333.8	-480.3	4,853.5
SHUTTLE PRODUCTION	1,053.0	1,189.6	-154.5	1,035.1
SHUTTLE OPERATIONS	2,999.9	3,006.5	-262.9	2,743.6
LAUNCH SERVICES	180.8	316.9	-3.4	313.5
SPACE COMMUNICATIONS	825.1	820.8	-59.5	761.3
CONSTRUCTION OF FACILITIES	520.0	550.3	-32.6	517.7
RESEARCH AND PROGRAM MANAGEMENT	1,634.8	1,675.0	-39.5	1,635.5
INSPECTOR GENERAL	14.6	15.5	-0.1	15.4
TOTAL	14,322.5	15,265.0	-713.6	14,551.4

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CHANGES FROM FY 1994 BUDGET ESTIMATE TO FY 1994 CURRENT ESTIMATE
INITIAL OPERATING PLAN
(Dollars in Millions)

RESEARCH AND DEVELOPMENT

	FY 1993 ACTUAL	FY 1994 AMENDED BUDGET ESTIMATE	FY 1994 CHANGE	FY 1994 CURRENT ESTIMATE
Space station	2122.5	1946.0	--	1946.0
Development		1909.0	-28.0	1881.0
Science and utilization		32.0	28.0	60.0
Assured crew rescue vehicle		5.0	--	5.0

CHANGE FROM FY 1994 BUDGET ESTIMATE

Funding for the Space Station remains at the requested level of $1,946.0 million. Within this funding level, $28 million has been reallocated from Development to Science and Utilization. Of this amount, $21 million has been allocated for payload user support and major payloads development has been increased by $7 million, reflecting the most current estimate of funding for major payloads and utilization support. This allocation of science and utilization funding is a change from the information submitted with the FY 1994 initial Operating Plan. This allocation increases the funding for payload development by $5 million to ensure timely provision of Space Station payloads and decreases the funding for utilization support consistent with current estimates for those requirements.

	FY 1993 ACTUAL	FY 1994 AMENDED BUDGET ESTIMATE	FY 1994 CHANGE	FY 1994 CURRENT ESTIMATE
Space transportation capability development.	649.2	705.0	42.4	662.6
Spacelab	114.4	139.9	-7.1	132.8
Engineering and technical base	214.2	203.4	-23.0	180.4
Payload operations	131.5	125.4	-25.0	100.4
Advanced programs	32.9	60.7	-23.4	37.3
Advanced launch technology	--	25.8	-5.8	20.0
Research operations support	142.8	149.8	-15.5	134.3
Russian-US activities	--	--	50.0	50.0
Advanced propulsion technology	10.0	--	--	--
Tethered satellite system	3.4	--	7.4	7.4

CHANGE FROM FY 1994 BUDGET ESTIMATE

The net reduction of $42.4 million reflects reductions directed by Congress in Advanced Programs (-$35 million), Payload Operations and Support Equipment (-$25 million), Research Operations Support (-$15.2 million), Advanced Launch Technologies (-$5.8 million) and Engineering and Technical Base (-$5 million). In addition, funding for Engineering and Technical Base is further reduced by $18 million as part of the overall Agency reduction of $50 million for support service contractors directed by Congress. Offsetting these reductions, funding increases directed by Congress are reflected for the Single Stage Centaur (+$10 million), the Solid Propulsion Integrity Program (SPIP) (+$1.6 million) and to expand joint U.S./Russian space activities (+$50 million). In addition $7.4 million has been reallocated from the Spacelab budget to support the Tethered Satellite System reflight mission.

Funding for Spacelab is reduced a net of $7.1 million. This reflects the reduction of $8.1 million, of which $7.4 million will be reallocated to the Tethered Satellite System (TSS) reflight mission. The $8.1 million reduction is achieved by reducing planned replacement of obsolete hardware and deleting the planned modifications for long duration Spacelab flights. This reduction will be offset by the reallocation of $1.0 million to support the pallet for the TSS reflight mission planned for early 1996.

Funding for Engineering and Technical Base is reduced by a total of $23.0 million. This reflects a general reduction of $5 million consistent with Congressional direction and an additional reduction of $18 million as part of the agency reduction allocated to Space Transportation Capability Development for support service contractors. These reductions will be achieved through reduced support to Class VI computer operations.

reduced funding for planned ADP equipment purchases and operations, and reduced levels of science and engineering lab support.

Funding for Payload Operations is reduced $25.0 million, reflecting the $25 million reduction directed by Congress. In addition, $12 million has been reallocated within Payload Operations to initiate development of a fiber optics cabling system to replace the cable harnesses in the payload bay of the orbiter. This will increase the lift capability of the Shuttle thereby enhancing its ability to support Space Station assembly, especially for high inclinations. These reductions will be achieved by reducing allowances for manifest variation and rephasing optional services for NASA payloads.

Funding for Advanced Programs is reduced $23.4 million. This reflects a general reduction of $35 million offset by an increase of $1.6 million for the Solid Propulsion Integrity Program (SPIP), and an increase of $10 million for the potential development of a single engine version of the Centaur upper stage. These changes are consistent with Congressional direction. The increase in SPIP funding will result in additional bondline and nozzle resolution activities, including improved material characterization testing and verification capability development. The general reduction will be achieved by significantly reducing planned activities in all areas of advanced studies, and represents a reduction of nearly 50 percent from current levels. Advanced Transportation tasks in vehicle health management will be deleted while work in aluminum-lithium alloys and electro-mechanical actuation (EMAs) will be severely scaled back. Work in Advanced Operations which represented investments in Shuttle flight and ground processing to reduce costs by introducing new technologies will be significantly reduced. New flight demonstrations which allow new technologies and techniques to be proven out in a space environment will be postponed. Within Advanced Programs, $1.5 million has been identified to complete a study by a consortium of private sector propulsion companies to identify the technologies required for United States leadership in commercial launch vehicles. Consistent with Congressional direction, $10 million has been identified for the potential development of a single engine version of the Centaur upper stage. These funds will not obligated until the multiyear funding plan and schedule of annual performance milestones have been provided the Committees, consistent with the direction in the Senate report.

Funding for Research Operations Support (ROS) is reduced a total of $15.5 million primarily reflecting Congressional direction. This reduction will be accommodated by reducing support for facility operations support, ADP and telecommunications support and other Center administrative support.

	FY 1993 ACTUAL	FY 1994 AMENDED BUDGET ESTIMATE	FY 1994 CHANGE	FY 1994 CURRENT ESTIMATE
SPACE SCIENCE	1577.5	1700.0	71.9	1771.9
US/Russian cooperative activities	--	--	50.0	50.0
Physics and astronomy	1103.8	1074.7	-7.1	1067.6
Advanced x-ray astrophysics facility	168.3	260.3	-19.0	241.3
Global geospace science	72.6	13.3	--	13.3
Relativity mission development	1.9	40.0	2.4	42.4
Shuttle/spacelab payload	94.1	--	--	--
Payload and instrument development	99.3	53.4	6.1	59.5
Explorer development	115.8	123.3	--	123.3
Mission operations and data analysis	415.4	416.2	4.5	420.7
Research and analysis	71.6	72.2	-1.1	71.1
Suborbital program	64.8	69.5	--	69.5
Information systems		26.5	--	26.5

CHANGE FROM FY 1994 BUDGET ESTIMATE

The net reduction of $7.1 million reflects Congressional direction. Funding for the Advanced X-ray Astrophysics Facility (AXAF) is reduced $19 million; funding for support service contractors is reduced $5.3 million as part of the overall agency reduction of $50 million for support service contractors directed by Congress. These reductions are partially offset by funding additions of $15.8 million for Mission Operations and Data Analysis (MO&DA) and $1.0 million for a study of the feasibility of establishing a national institute of space science within NASA. $0.4 million is transferred to Space Science Information Systems from Mission To Planet Earth (MTPE) Information Systems. In the FY 1994 appropriation, Congress directed NASA to cease work on the AXAF-S spacecraft and to investigate the potential for flight of the X-Ray Spectrometer (XRS) instrument on Astro-E, a future Japanese mission. Consistent with the direction, the program has taken the necessary actions to terminate the AXAF-S mission. As part of a joint U.S.-Japanese cooperative effort, FY 1994 funds are being used to examine the technical, schedule and fiscal requirements for flying XRS aboard the Astro-E mission.

Although current funding for the Global Geospace Science (GGS) program is adequate to support the scheduled launches of Wind in the Spring of 1994 and Polar in the Summer of 1994, the prime contractor's schedule performance warrants concern as to whether these launch dates will be met. The program is under review to assess the situation and, it is likely that additional FY 1994 funds will be required.

A new program element entitled Relativity Mission Development has been established, and includes funds for the Gravity Probe-B (GP-B) and the Shuttle Test of Relativity Experiment program. The STORE program has focused on technology development and studies for a future GP-B mission. FY 1994 GP-B development funds are budgeted at $40 million. The $2.4 million which was included for STORE activities in Payload and Instrument Development are transferred to this new program element, resulting in a consolidated budget of $42.4 million.

Payload and Instrument Development is increased a net of $6.1 million. This reflects additional funding for the Collaborative Solar Terrestrial Research (COSTR) program ($6.1 million) and the Tether Satellite System (TSS) reflight mission ($2.4 million) offset by the transfer of funds for the STORE mission addressed above. Funding for the COSTR and TSS is reallocated from the $22.5 million added by the congress to the Space Science program for Mission Operations and Data Analysis activities. A portion of the $22.5 million augmentation had been intended by Congress for Hubble Space Telescope (HST) Operations and Servicing. Funding for HST Operations and Servicing has been augmented by $15 million of prior year funds resulting from the recent settlement between the U.S. Department of Justice and the Hughes-Danbury Optical Systems Corporation relating to the claim of defective workmanship in production of the main mirror of the HST. The additional requirement of $6.1 million for the COSTR program is due to problems experienced during qualification of the Multi-Anode Microchannel Array (MAMA) detectors. $2.4 million is also included in Payload and Instrument Development to support reflight of the TSS in 1996. Funding for this activity was not included in the FY 1994 budget request. Additional funds are required in FY 1994 for refurbishment, planning and scientific support for this unique engineering and scientific demonstration. Funding for the TSS Reflight mission is also included in the Space Transportation Capability Development budget.

Funding for MO&DA is increased $4.5 million. This increase reflects an allocation of $7.3 million of the total increase of $22.5 million in Space Science MO&DA directed by Congress. These funds will be used to support ongoing activities in the Space Physics MO&DA program. This increase is partially offset by a decrease to the HST Operations and Servicing of $2.8 million as part of the reduction of $50 million directed by Congress for support service contractors.

Funding for Research and Analysis is decreased a net of $1.1 million. Space Physics Supporting Research and Technology (SR&T) is reduced $2.1 million as part of the reduction in funding for support service contractors directed by Congress. This reduction has been offset by the addition of a $1 million study directed by Congress on the merits of establishing a national institute of space science within NASA.

Funding for Information Systems is unchanged; however, reallocations within the program have been made. When the Office of Space Science and Applications was recently reorganized, the Information Systems program was split between the Office of Space Sciences (OSS) and the Office of Mission to Planet Earth (OMTPE). The Supercomputing and the NASA Center for Computational Science (NCCS) programs are now managed by OMTPE, while the remainder of the program is to be managed by OSS. When the funds were reallocated between the two

program offices. ROS funding associated with the program was not distributed accordingly. Therefore, a $0.4 million transfer from OMTPE to OSS is required to properly reflect the new program structure. This increase is offset by an reduction of $0.4 million for support service contractors, as part of the overall Agency reduction.

		FY 1994		
	FY 1993 ACTUAL	AMENDED BUDGET ESTIMATE	CHANGE	CURRENT ESTIMATE
Planetary exploration	473.7	625.3	29.0	654.3
Cassini	205.0	266.6	--	266.6
Mars '94	3.5	3.5	--	3.5
Discovery	--	68.1	59.3	127.4
Mission operations and data analysis	163.5	160.7	-19.0	141.7
Research and analysis	101.7	126.4	-11.3	115.1

CHANGE FROM FY 1994 BUDGET ESTIMATE

This increase reflects Congressional direction to initiate development of the Near Earth Asteroid Rendezvous (NEAR) mission (+$64.3 million), reduce funding for Mars Observer MO&DA (-$24 million) and terminate the High Resolution Microwave Survey (HRMS) program (-$11.3 million). Other changes consistent with Congressional action include a reduction to support service contractors funded within MO&DA (-$1.7 million) and allocation of a portion of the Congressional MO&DA augmentation to extend Magellan operations (+$6.7 million). In addition, the Mars Environmental Survey (MESUR) Pathfinder Microrover development ($5 million) has been transferred to the Office of Advanced Concepts and Technology (OACT).

Funding for the Discovery program is increased a net of $59.3 million, representing the net effects of adding the $64.3 million directed in the Conference report for NEAR and transferring $5 million to OACT for development of the MESUR/Pathfinder microrover. Launch of NEAR is targeted for February 1996 aboard a Delta launch vehicle.

Planetary MO&DA is reduced a net of $19 million. This reflects Congressional reductions in Mars Observer (-$24 million) and funding for support contractors (-$1.7 million), offset by increased funding of $6.7 million for Magellan extended mission operations. The reduction in funding for support contractors will require termination of Voyager Neptune data analysis by mid-FY 1994 (-$1.4 million) and deferral of planned activities in Planetary Flight Support (-$0.3 million). The additional funding in Magellan operations will extend mission operations through the second half of FY 1994. The spacecraft successfully completed an aerobraking experiment in FY 1993 which circularized the orbit, and continues to acquire global high

resolution gravity data. Consistent with Congressional direction, $10.3 million of Mars Observer MO&DA funds have been retained for a Mars Orbiter mission in 1996, designed to acquire much of the data which was to have been obtained by the Mars Observer. NASA will forward a plan for the use of these funds and the unearned orbital performance fee as soon as possible.

Funding for Research and Analysis is reduced $11.3 million consistent with Congressional direction to cancel the High Resolution Microwave Survey (HRMS) program. The $1 million provided in FY 1994 is sufficient to cover the minimum legal requirements for program termination. However, additional funding is required to ensure that the existing hardware is adequately documented and prepared for storage in proper working condition. This will preserve the hardware for potential use by other users, and facilitate the use of this technology for other applications. To this end, up to $1 million of FY 1993 Planetary Research and Analysis (R&A) funds will be used. Within the R&A budget, $2 million has been allocated to support the release of Phase A study contracts for spacecraft design options in support of a potential Mars Observer recovery mission.

	FY 1993 ACTUAL	FY 1994 AMENDED BUDGET ESTIMATE	FY 1994 CHANGE	FY 1994 CURRENT ESTIMATE
Life and microgravity sciences and applications	139.5	470.0	6.3	476.3
Life sciences	139.5	188.9	-0.7	188.2
Research and analysis	52.9	49.2	5.9	55.1
Flight experiments	86.6	139.7	-6.6	133.1
Microgravity research	(173.9)	163.4	13.2	176.6
Research and analysis	(17.9)	18.4	--	18.4
Flight experiments	(156.0)	145.0	13.2	158.2
Shuttle/spacelab payload mission management and integration	(94.1)	117.7	-6.2	111.5

CHANGE FROM FY 1994 BUDGET ESTIMATE

The net increase of $6.3 million reflects Congressional direction, and is the result of the addition of $15 million for NASA/National Institute of Health (NIH) collaboration, offset by reductions in funding for Flight Experiments ($5.2 million), Mission Management ($-5.0 million), and support contractors (-$5.0 million). In addition, funding for the Life Support Program ($6.5 million) has been transferred from the Office of Advanced Concepts and Technology to the Office of Life and Microgravity Sciences. The objective of the Life Support Program is to create a stronger technology base in advanced life support systems, extravehicular activity, and human factors engineering. The approach will be to develop coordinated, cooperative solutions between NASA, universities and industry. By making the activities of this program more relevant to NASA's near-term missions, success with this element will reduce the U.S.'s long-term reliance on non-U.S. technologies.

The augmentation of $15 million for the NASA/NIH collaboration will be directed at the discipline of Biotechnology. It will be focused on supporting the research activities selected in response to the NASA/NIH Biotechnology NASA Research Announcement (NRA)($12 million) as well as activities in support of the NASA/NIH Biotechnology Technology Transfer ($3 million). The NRA will be done in collaboration with the National Institute for Allergies and Infectious Diseases and the National Cancer Institute, and will fund 30 additional Principal Investigators in the area of biotechnology. The NASA/NIH Biotechnology Transfer will be a joint Cooperative Agreement to exploit the Bioreactor cell culture apparatus for colon, breast, ovarian and liver cells and explore the utilization of cell culture-specific bioreactors in research hospitals within the United States.

The $5.2 million reduction in Life Sciences Flight Experiments will be achieved through reducing Spacelab program activities and associated base support as well as deferring specific mission activities. The reduction of $5 million in Spacelab Mission Management will be accommodated by deferring the planned buildup in systems engineering manpower in support of FY 1994-1995 planned missions, in an effort to more efficiently conduct these activities. The reduction of $5 million in funding for support contractor manpower will be achieved by accelerating cost saving measures planned for initiation in FY 1995.

	FY 1993 ACTUAL	FY 1994 AMENDED BUDGET ESTIMATE	FY 1994 CHANGE	FY 1994 CURRENT ESTIMATE
Mission to planet Earth	1,154.0	1,112.9	-44.5	1,068.4
Earth observing system	263.8	322.7	-3.9	318.8
Earth observing system data information system	130.7	182.7	5.5	188.2
Earth probes	99.4	97.3	-0.9	96.4
Payload and instrument development	35.4	22.9	--	22.9
ACTS development	4.0	3.0	--	3.0
Applied research and development	339.5	417.3	-42.1	375.2
Research operations support	70.1	67.0	-3.1	63.9
Materials processing	173.9			
Information systems	36.2			
Search and rescue	1.0			

CHANGE FROM FY 1994 BUDGET ESTIMATE

The reduction of $44.5 million reflects a reduction of $36.1 million as the result of specific Congressional direction, an additional reduction of $8 million as part of the total Agency reduction of $50 million for Support Contractor manpower and the aforementioned transfer of $0.4 million to Physics and Astronomy/Information Systems.

Funding for the Earth Observing System is reduced $3.9 million, $1.9 million for the support contractor reduction and $2 million for the reduction directed by Congress, accommodated by reducing program flexibility. Funding for the Earth Observing System (EOS) Data Information System (EOSDIS) is increased $5.5 million, the net effect of reducing support contractors by $1.5 million and the increase of $7 million, consistent with Congressional direction, to augment program reserves for the development of the EOSDIS Core System. Funding for Earth Probes is reduced $0.9 million for the support contractor reduction. Funding for Applied Research, Data Analysis (AR&DA) and Related is reduced $42.1 million, $3.7 million for the support

contractor reduction, an additional $38.0 million consistent with Congressional direction as specified below, and transfer of $0.4 million to Physics and Astronomy/Information Systems. The amount requested for the Consortium for International Earth Science Information Network (CIESIN) has been reduced $13 million, the impact of which will be mitigated by the availability of unobligated FY 1993 funds. Funding for the Landsat program has been reduced $5 million. This reduction effects the ability of the program to respond to technical or schedule difficulties that may arise in the planned development activities associated with NASA's responsibility to develop the Landsat ground system. The $20 million in the budget request for the Science Data Purchase program was deleted by Congress.

NASA will continue the Optical Transient Detector (OTD) activity initiated in FY 1993 under AR&DA and for which FY 1994 funds were requested under the Science Data Purchase program. The OTD will provide early acquisition of science data to support research in determining global distribution of lightning and its effects on climate change. The OTD will also be a pathfinder for commercial remote sensing applications of lightning data. NASA has reallocated $3.25 million from within Mission to Planet Earth, AR&DA for this activity.

Funding for Research Operations Support is reduced $3.1 million, which will be accommodated through reduced institutional support available at Headquarters and the Goddard Space Flight Center.

	FY 1993 ACTUAL	FY 1994 AMENDED BUDGET ESTIMATE	FY 1994 CHANGE	FY 1994 CURRENT ESTIMATE
Advanced concepts and technology	437.1	521.4	-88.7	432.7
Space transportation	87.8	84.6	-12.8	71.8
Spacecraft and remote sensing	140.8	166.0	-10.0	156.0
Advanced smallsat	--	30.0	-17.5	12.5
Space communications	32.1	30.3	0.7	31.0
Space processing	31.9	29.7	-13.2	16.5
Flight programs	115.0	132.7	-35.3	97.4
Technology transfer	29.5	28.1	-0.3	27.8
Industry technology program	--	20.0	-0.3	19.7

CHANGE FROM FY 1994 BUDGET ESTIMATE

Beginning in FY 1994, the Space Research and Technology program and Commercial Programs have been combined to form the Office of Advanced Concepts and technology.

The total reduction to Advanced Concepts and Technology of $88.7 million reflects Congressional direction as well as funding reallocations between program offices. Reductions taken consistent with Congressional direction include: general reductions of $28.7 million for Space Research and Technology and $8.4 million for Commercial Programs; the Commercial Middeck Augmentation Module (CMAM) (-$21.5 million); the Commercial Experiment Transporter (COMET) (-$10.1 million); and Smallsat (-$17.5 million). The CMAM contractor Spacehab, and NASA have rescheduled the Spacehab launch schedule and resolved the funding shortfall resulting from the Conference action. The reduction in FY 1994 has been offset by a commensurate increase in the FY 1995 request for CMAM. A reduction of $5 million is included as part of the general Agency reduction of $50 million directed in the Conference Report for Support Service manpower, and is allocated throughout the program. In addition, $6.5 million is transferred to the Office of Life and Microgravity for the Life Support Program. Consistent with Congressional direction, funding is increased for the Advanced Communications Technology Satellite (+$2.5 million). The funding also reflects the transfer from Space Science for the development of the microrover for the MESUR/Pathfinder mission (+$5 million) and provision for artificial intelligence and software reuse activities in conjunction with the Department of Defense (+$1.5 million).

The general reduction directed to Space Research and Technology will be accommodated by reducing activities in Space Transportation (-$11.4 million), Spacecraft and Remote Sensing (-$13.6 million), Space Communications (-$1.4 million) and Flight Systems (-$2.3 million). In Space Transportation, all NASA work

in chemical upper stages will be terminated, including an effort to develop a testbed which was to be used by industry and NASA as part of a long-term effort to develop component and system level technology for cost effective, reliable and operable upper stage propulsion systems. The reduction in Spacecraft and Remote Sensing will be accommodated by deleting ongoing efforts planned to support future commercial and NASA missions in Space Science and Earth applications. Some activities planned in the Science Sensors and Instrument Systems Program will be deleted or delayed. These technology development efforts are closely planned with technology teams made up from the NASA offices representing these science disciplines. Extensive replanning will be conducted with these representatives to ensure the technology program pursued is supportive of the customers' needs. The general reduction directed to Commercial Programs will be allocated against the Centers for the Commercial Development of Space (CCDS) and the supporting programs.

		FY 1994		
	FY 1993 ACTUAL	AMENDED BUDGET ESTIMATE	CHANGE	CURRENT ESTIMATE
Aeronautical research and technology........	865.6	1,020.7	-13.7	1,007.0
Research operations support	148.8	143.5	-6.7	136.8
Research and technology base	436.5	448.3	-4.0	444.3
Systems technology programs	280.3	428.9	-3.0	425.9
High performance computing...............	30.4	65.6	--	65.6
Materials and structures.................	36.6	25.7	--	25.7
Rotorcraft...............................	7.0			
High-performance aircraft................	12.1			
Advanced propulsion......................	16.9			
Numerical aerodynamic simulation.........	47.9	49.1	-1.0	48.1
High-speed research......................	117.0	187.2	10.0	197.2
Advanced subsonic technology.............	12.4	101.3	-12.0	89.3

CHANGE FROM FY 1994 BUDGET ESTIMATE

The reduction of $13.7 million reflects a net reduction of $7.7 million consistent with specific Congressional direction, and the additional reduction of $6.0 million as part of the total agency reduction of $50 million for Support Contractor manpower. These reductions will be accommodated through reductions to the Research and Technical (R&T) Base (-$5 million) and the Numerical Aerodynamic Simulation program (-$1.0 million), and will be achieved by eliminating support service manpower for the lowest priority tasks at Headquarters and the Research Centers. The reduction to the R&T Base includes a $1 million set-aside for an

assessment of whether a National Institute for Aeronautics should be established within NASA, consistent with Congressional direction.

Within the R&T base, we have identified $5 million to foster the technological changes necessary for increasing the global competitiveness of the U.S. rotorcraft industry through the coming decade. This effort, referred to as the Rotorcraft Industry TEchnology (RITE) program, will involve the triad of government, industry, and academia in an unique and innovative partnership. The program will rely heavily on the proactive participation of the industry in the research programs implemented through two institutes. The two institutes will be headed by NASA employees and located at academic sites in the southwestern and northeastern U.S. The program's uniqueness will be reflected by the degree of industry control in identifying and selecting the tasks to be undertaken in the program, the matching of government funds by industry participants, and the disposition of the intellectual property.

Funding for High Speed Research has been increased $10 million as directed by Congress. This funding will be utilized to both accelerate and expand high priority needs in the individual technology areas and related integration efforts. Identification, ranking and selection of these needs is now underway, and involves strong participation by our industry partners to achieve a consensus on the most productive and efficient application of this funding.

Funding for Advanced Subsonic Technology (AST) has been reduced $12.0 million consistent with Congressional direction. In addition to amounts already planned, additional AST funds have been allocated to take advantage of the current aircraft sales market in replacing the current Transport Systems Research Vehicle (TSRV). This aircraft is currently the oldest flying B-737 aircraft and can no longer support research in advanced flight deck and flight controls. The plan is to replace the current TSRV with advanced flight deck and flight controls. The plan is to replace the current TSRV with a B-757, at a cost of $24 million over three years, FY 1994-1996. This upgrade is critical to the Terminal Aero Productivity element of the AST program and will be used to flight test and evaluate, in conjunction with FAA and U.S. industry, technology and procedures to achieve increased capacity in the terminal area during poor weather conditions. In addition, the TSRV is an important asset in support of the fly-by-light/power-by-wire element of the AST. The general reduction, as well as the reallocation of funds for the TSRV upgrade, will be accommodated by reducing funding for three AST program activities - the Enhanced Vision System Technology, the Environmental Research Aircraft and Remote Sensor Technology activity, and the Sixty (60) Atmosphere Combuster Test Rig. This funding reduction will delay for one year the initiation of development activities planned for FY 1994.

Funding for Research Operations Support is reduced $6.7 million consistent with Congressional direction. This reduction will be accommodated by eliminating low priority institutional activities at the Aeronautical Research Centers.

	FY 1993	FY 1994		
	ACTUAL	AMENDED BUDGET ESTIMATE	CHANGE	CURRENT ESTIMATE
Transatmospheric research and technology....	0.0	80.0	-60.0	20.0

CHANGE FROM FY 1994 BUDGET ESTIMATE

This reduction is consistent with Congressional direction. This funding will be applied directly to the program to complete the National Aero-Space Plane (NASP) technology development phase, which features the upcoming Concept Demonstration Engine (CDE) test series. NASA is working with the Department of Defense to formulate a successor hypersonics research and development program.

	FY 1993	FY 1994		
	ACTUAL	AMENDED BUDGET ESTIMATE	CHANGE	CURRENT ESTIMATE
Academic programs.........................	92.9	74.5	11.0	85.5

CHANGE FROM FY 1994 BUDGET ESTIMATE

This increase of $11.0 million is consistent with Congressional direction. Of this amount, $3.0 million will be used to augment the scope of the overall education technology program, and $8.0 million will increase the level of funding for Minority University Research. The latter amount will be applied as follows: Historically Black Colleges and Universities (HBCU) will be increased by $5 million to increase funding at HBCUs currently receiving very little NASA funding, and to initiate pilot Mathematics, Science and Technology Teacher and Curriculum Enhancement programs in a few HBCUs; Other Minority Universities will be increased by $2.5 million to augment NASA's Hispanic Institution Initiative. This includes funding for Institutional Research awards, Faculty research awards, and Math, Science and Technology Teacher awards. In addition, consistent with Congressional direction, NASA will work with the National Science Foundation to enhance the strategic planning and capabilities of a small number of HBCUs; $0.5 million is planned for this effort.

	FY 1993 ACTUAL	FY 1994 AMENDED BUDGET ESTIMATE	FY 1994 CHANGE	FY 1994 CURRENT ESTIMATE
Safety, reliability & quality assurance.....	32.7	35.3	-1.0	34.3

CHANGE FROM FY 1994 BUDGET ESTIMATE

The current FY 1994 estimate reflects a $1.0 million reduction in support contractor funding, as part of the overall reduction directed by Congress.

	FY 1993 ACTUAL	FY 1994 AMENDED BUDGET ESTIMATE	FY 1994 CHANGE	FY 1994 CURRENT ESTIMATE
Tracking and data advanced systems..........	23.3	24.6	--	24.6

SPACE FLIGHT CONTROL, AND DATA COMMUNICATIONS

	FY 1993 ACTUAL	FY 1994 AMENDED BUDGET ESTIMATE	FY 1994 CHANGE	FY 1994 CURRENT ESTIMATE
Shuttle production	1,053.0	1,189.6	-154.5	1,035.1
Orbiter operations capability	297.0	297.2	-69.8	227.4
Propulsion systems	293.4	297.9	30.1	328.0
Advanced solid rocket motor (ASRM)	195.0	280.4	-100.7	179.7
Launch and mission support	178.1	173.9	-14.1	159.8
Safety and obsolescence	89.5	140.2	--	140.2

CHANGE FROM FY 1994 BUDGET ESTIMATE

This net reduction of $154.5 million reflects Congressional reductions of $217.4 million, partially offset by the addition of $62.9 million to accommodate new requirements.

In Orbiter, the structural spares program has been terminated consistent with Congressional direction. The remaining amount of $5 million will be used for termination costs. An additional reduction of $39.8 million has been incorporated based on a reassessment of anticipated orbiter modifications and change traffic. The modifications to support the first flight to the Russian Mir to support a June 1995 docking remain unchanged. Although the funding for the Long Duration Orbiter has not changed, the program is currently evaluating the requirements for the capability based on the configuration for the Space Station.

In Propulsion, total funding is increased $30.1 million. $60 million has been reallocated to support development of a Super Lightweight External Tank utilizing an aluminum-lithium alloy.

Funding for the Advanced Solid Rocket Motor is reduced a net of $100.7 million. This reflects the reduction of $180.4 million directed by Congress, offset by reallocation of $79.7 million in order to accommodate the additional funding of $179.7 million required to cover termination costs. In response to discussions with the Thiokol Corporation, the manufacturer of the redesigned Solid Rocket Motor (RSRM), about the use of facilities at the Yellow Creek, MS site, we have initiated a study with Thiokol to investigate the feasibility of performing RSRM and other solid rocket motor nozzle manufacturing and RSRM nozzle refurbishment at Yellow Creek. Our preliminary assessment indicates a funding requirement of approximately $13 million in FY 1994, consistent with Thiokol capitalizing facilities modifications and equipment procurement. NASA considers the Thiokol proposal meritorious because it is consistent with the Agency's

desire to upgrade the RSRM manufacturing processes, it enables some return on the Government's investment in the Yellow Creek site, and it mitigates the economic impact on the region from the termination.

In addition, funding for other Propulsion activities has been reduced $43.1 million, due to reduced requirements for materials procurement in the Solid Rocket Booster, less than anticipated Space Shuttle Main Engine attrition needs and a reduction in support activities.

Funding for Launch and Mission Support has been reduced $14.1 million, reflecting the general reduction of $5 million directed by Congress and an additional reduction of $9.1 million. This total reduction is accommodated by rephased aircraft modifications and lower than planned costs for the Launch Processing System upgrade at the Kennedy Space Center.

Funding for Safety and Obsolescence is unchanged. Consistent with Congressional direction, no funds are included for initiating development of the alternate fuel pump; however we are concerned that its deferral delays the availability of a critical safety enhancement to the Shuttle system and impacts the planned block change for the main engines. The delay will also increase the total cost.

		FY 1994		
	FY 1993 ACTUAL	AMENDED BUDGET ESTIMATE	CHANGE	CURRENT ESTIMATE
Shuttle operations	2,999.9	3,006.5	-262.9	2,743.6
Flight operations	747.1	767.8	-93.7	674.1
Flight hardware	1,387.1	1,364.6	-113.0	1,251.6
Launch and landing operations	690.8	696.4	-56.2	640.2
Research operations support	174.9	177.7	--	177.7

CHANGE FROM FY 1994 BUDGET ESTIMATE

This reduction of $262.9 million reflects a Congressional reduction of $200 million as well as an additional $62.9 million to offset the additional funding requirements discussed above. Reductions have been made in each of the budget elements, although an unresolved shortfall of $59.1 million still remains. The program will continue to assess our requirements and cost performance during the year to insure adequate resources are available, and keeping the Congress apprised of our progress.

The reduction in Flight Operations of $78.7 million is achieved through reductions in operations and training and engineering support manpower. Flight Hardware funding is reduced $83.0 million due to the restructuring of the External Tank contract, reduced levels of engineering support manpower and other

efficiencies. Launch and Landing Operations is reduced $42.1 million based primarily on limiting overtime at the launch site.

	FY 1993 ACTUAL	FY 1994 AMENDED BUDGET ESTIMATE	FY 1994 CHANGE	FY 1994 CURRENT ESTIMATE
Launch services	180.8	316.9	-3.4	313.5

CHANGE FROM FY 1994 BUDGET ESTIMATE

This net reduction of $3.4 million reflects the Congressional general reduction of $10.0 million offset by the addition of $6.6 million for initial launch vehicle support for the NEAR mission, scheduled for launch in February 1996. The general reduction will be accommodated by reductions in funding for the AXAF-I upper stage (-$7.5 million) and medium expendable launch vehicle sustaining support (-$2.5 million).

	FY 1993 ACTUAL	FY 1994 AMENDED BUDGET ESTIMATE	FY 1994 CHANGE	FY 1994 CURRENT ESTIMATE
Space communications	825.1	820.8	-59.5	761.3
Space network	227.1	173.9	-60.4	113.5
Ground network	306.6	316.3	-5.0	311.3
Communications and data systems	291.4	330.6	5.9	336.5

CHANGE FROM FY 1994 BUDGET ESTIMATE

Congressional action reduced this account by $59.5 million, reflecting deletion of funding, without prejudice, for the Tracking and Data Relay Satellite (TDRS) Replenishment (-$48 million), a general reduction of $11 million, and a specific reduction of $0.5 million for Mars Observer tracking support. In addition to those actions, internal allocation of $11.0 million has been made within the program to consolidate funding for program support activities.

The general reduction of $11 million has been accommodated through reductions to the Space Network, Ground Network, and Communications and Data Systems budget elements. The Conference Report included direction to reduce funding for Space Communications activities at Headquarters and ground terminal operations by $8.6 million. A plan is in place to eliminate nearly all support activities at Headquarters, and funding for these activities has been reduced $3.6 million. To avoid any adverse impact to the NASA Ground Terminal

operations, however, the remaining $7.4 million of this general reduction has been accommodated in reductions described further.

In Space Network, there is a net funding reduction of $60.4 million. Funding for the TDRS Replenishment program is reduced $45.4 million. The requested funding for this activity of $48 million was not included in the Conference Report, although the Report indicated a reprogramming request would be entertained. By the end of the decade, many of the initial TDRS satellites will have exceeded their expected lifetimes. Replenishment spacecraft are needed in orbit to sustain space network operations for existing spacecraft. In order to ensure that new spacecraft are available beginning in 1999, release of a Request for Proposal (RFP) for the Replenishment TDRS spacecraft is scheduled for early 1994. $2.6 million has been included to support the procurement activities. Funding for the Second TDRS Ground Terminal (STGT)/White Sands Upgrade (WSUG) program is reduced $8.7 million as part of the total reduction for Space Communications based on rephased program requirements, consistent with the July 1993 Project Status Report. These changes reflect a redistribution of program reserves based on a recent assessment of the program. Total expected costs for the STGT/WSUG program remain unchanged at $575 million. Funding for other Space Network program elements is reduced $6.3 million. This reduction reflects the transfer of funding for program integration activities into Communications and Data Systems (-$9.8 million) offset by an increase of $3.5 million for software enhancements to the Network Control Center for operation of more than three TDRS satellites.

In Ground Network, funding is reduced $5.0 million. This reflects the reduction of $0.5 million for Mars Observer support, the transfer of $1.2 million for program integration activities into Communications and Data Systems and an additional reduction of $3.3 million as part of the general reduction directed by Congress. In addition, funding has been reallocated to meet several program requirements which have emerged. $7.6 million has been reallocated to fund the modifications of two 34-meter antennas transferred to NASA by the U.S. Army. These antennas will augment the current 34-meter capability at Goldstone to accomplish the Galileo encounter at Jupiter. $5.8 million has been reallocated to support tracking requirements for inclusion of the NASA Scatterometer instrument on the Japanese ADEOS mission. To meet these new requirements, as well as accommodate the $3.3 million general reduction, all program flexibility will be eliminated and contractor support of the Deep Space Network, the Spaceflight Tracking and Data Network program and the ground network will be reduced.

In Communications and Data Systems, funding is increased a net of $5.9 million. This reflects changes due to the consolidation of program integration activities as well as a general reduction, accommodated by reductions primarily to communications, data capture and data processing functions. In addition, $4.3 million has been reallocated to begin consolidation of the Spacelab data processing activities at the Marshall Space Flight Center. To accommodate this reallocation, planned equipment purchases for the NASCOM and PSCN will be deferred and operations support reduced.

	FY 1993 ACTUAL	FY 1994 AMENDED BUDGET ESTIMATE	FY 1994 CHANGE	FY 1994 CURRENT ESTIMATE
CONSTRUCTION OF FACILITIES	520.0	550.3	-32.6	517.7

CHANGE FROM FY 1994 BUDGET ESTIMATE

This reduction is consistent with Congressional direction and reflects the termination of the ASRM program. Consistent with Congressional direction, no funding is included for the Neutral Buoyancy Laboratory at the Johnson Space Center. However, a review of the technical and schedule readiness of this facility will be undertaken by an independent panel composed of outside experts to establish the technical requirements and readiness of this project. A similar evaluation for the Earth Systems Science Building being planned for the Goddard Space Flight Center is planned.

	FY 1993 ACTUAL	FY 1994 AMENDED BUDGET ESTIMATE	FY 1994 CHANGE	FY 1994 CURRENT ESTIMATE
RESEARCH AND PROGRAM MANAGEMENT	1,635.0	1,675.0	-39.5	1,635.5
Personnel and related cost	1,587.8	1,623.5	-34.0	1,589.5
Travel	47.2	51.5	-5.5	46.0

CHANGE FROM FY 1994 BUDGET ESTIMATE

The reduction of $39.5 million reflects Congressional direction, which assumed NASA would achieve sufficient retirements to achieve an end-of-year full time equivalent (FTE) level of 22,900. These reductions appeared attainable prior to the imposition of the requirement to implement the locality pay increase ($45.6 million) and the failure of the Congress to enact legislation to incentivize employees to retire. We have placed into effect severe internal expenditure constraints and hiring limitations, consistent with striving to minimize the impacts of implementing the statutory pay increase and achieving the total FTE employment ceiling of 22,900. Legislation is proposed in the President's budget request to rescind $95.0 million in other accounts and make supplemental appropriations of $60.0 million to this account to meet the additional funding requirements from implementing locality pay and offsetting higher salary and benefits costs due to the greatly reduced rate of attrition.

		FY 1994		
	FY 1993 ACTUAL	AMENDED BUDGET ESTIMATE	CHANGE	CURRENT ESTIMATE
INSPECTOR GENERAL..........................	15.1	15.5	-0.1	15.4

CHANGE FROM FY 1994 BUDGET ESTIMATE

This reduction reflects Congressional direction and will be accommodated by reducing program activities.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FISCAL YEAR 1995 ESTIMATES
ANALYSIS OF NASA/RUSSIAN COOPERATIVE MIR PROGRAM

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
HUMAN SPACE FLIGHT			
Russian cooperation*	79,500	170,800	150,100
(Russian support)	--	(100,000)	(100,000)
(Shuttle/spacelab support)	(79,500)	(70,800)	(50,100)
Space station (Flight technology demonstrations)*	--	--	40,000
SCIENCE, AERONAUTICS AND TECHNOLOGY			
Russian cooperation*	15,400	54,100	61,800
(Life sciences)	(7,600)	(33,800)	(18,700)
(Microgravity)	(4,400)	(5,800)	(18,400)
(Spacelab mission management)	(3,400)	(14,500)	(24,700)
Total	94,900	224,900	251,900

Note: Does not include several cooperative developments still under definition (e.g., solar-thermal dynamic power, common spacesuit, environmentally-controlled life support system)

* Russian cooperation program elements are also included under the special analysis of the Agency's Space Station-related support.

The cooperative U.S./Russian Mir program consists of a minimum of six (with a maximum of ten) flights of the Space Shuttle to the Mir Space Station with the objective of conducting a joint experiment program for microgravity, life sciences and technology demonstration as well as extending the life of the Mir station through 1997. At least four flights will carry a pressurized Spacelab module carrying experiments and providing logistics support. Initial flight is planned for mid-1995. During this period, Russia will enhance the Mir capabilities by adding two experiment/logistics modules to the core Mir station (Spektr and Priroda) which will also include U.S. hardware. Russian support funding provides for hardware and services provided by Russia on a firm-fixed-price contractual basis which will benefit the joint Mir activities (Phase 1) as well as future Space Station-related design, technologies and other services (Phase 2/3).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FISCAL YEAR 1995 ESTIMATES
ANALYSIS OF AGENCY SUPPORT FOR SPACE STATION

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
HUMAN SPACE FLIGHT			
Space station	2,162,000	1,937,000	1,889,600
Russian cooperation	79,500	70,800	50,100
SCIENCE, AERONAUTICS & TECHNOLOGY			
Life and microgravity sciences and applications			
Russian cooperation	15,400	54,100	61,800
(Life sciences)	(7,600)	(33,800)	(18,700)
(Microgravity)	(4,400)	(5,800)	(18,400)
(Spacelab mission management)	(3,400)	(14,500)	(24,700)
Space station facility payloads	5,500	39,000	84,000
Space station utilization	--	3,300	10,600
Mission to planet earth			
Space station attached payload	--	--	9,800
Advanced concepts and technology			
Space station experiments	--	--	15,000
Total	2,262,400	2,104,200	2,120,900

Space station-related activities are funded in FY 1995 in the Human Space Flight (HSF) appropriation and in the Science, Aeronautics & Technology (SA&T) appropriation. The HSF funds the development and operation of the Space Station, in addition to the flight support component of the Russian cooperation program of joint flights to the Mir Space Station. Both programs are managed by the Office of Space Flight. Station-related funding in SA&T provides for the development, operation and science research associated with the scientific, technology and commercial payloads being built for utilization of the Space Station or in conjunction with the joint Mir program. The majority of these activities are managed by the Office of Life and Microgravity Sciences and Applications for these discipline-specific experiments. An externally-attached Space Station payload is being developed by the Office of Mission to Planet Earth. The Office of Advanced Concepts and Technology is providing technology and commercial payloads for both external and pressurized Space Station deployment.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUMAN SPACE FLIGHT

FISCAL YEAR 1995 ESTIMATES

GENERAL STATEMENT

The Human Space Flight appropriation provides funding for NASA's human space flight activities. This includes the on-orbit infrastructure (Space Station and Spacelab), transportation capability (Space Shuttle program, including operations, program support and performance and safety upgrades), and the Russian Cooperation program, which includes the flight activities associated with the cooperative research flights to the Russian Mir Space Station. These activities are funded in the following budget line items:

Space Station - The Space Station will be an orbiting laboratory which will enable unique scientific and technological investigations in a microgravity environment and provide the essential understanding of the ability of humans to live and work in space for extended periods of time. Funding will support continued development of the Space Station, which was significantly redesigned in 1993 and now includes major participation by Russia. Funding for Shuttle/Space Station Integration, previously included in Space Transportation Capability Development is included in this budget. Funding for Space Station-unique facilities previously included in the Construction of Facilities appropriation is included in the Space Station budget.

Russian Cooperation - This program includes all flight activities in support of the joint space missions involving the Space Shuttle and the Russian Mir Space Station. This includes the Shuttle and Spacelab-unique requirements associated with Shuttle flights to Mir, as well as the funding for contractual services and supplies to be provided by Russia in conjunction with the joint Mir program and the international Space Station. Funding for experiments for the Mir flights is included in the Life and Microgravity Sciences and Applications and Space Station budgets.

Space Shuttle - This supports all the activities required for the continuing, safe operation of the Space Shuttle. This includes the hardware and support services to maintain the Shuttle launch schedule, and funding for activities to enhance the safety and performance of the Space Shuttle. These activities were previously budgeted in the Space Flight Control, and Data Communications appropriation. Funding for Space Shuttle-unique facilities previously included in the Construction of Facilities appropriation is included in the Space Shuttle budget.

Payload Utilization and Operations - Funding is provided for the support of payloads flying on the Shuttle and Spacelab, as well as advanced technology projects and Engineering Technical Base support for the field centers supporting Human Space Flight activities. Funding for these activities was previously included in Space Transportation Capability Development.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUMAN SPACE FLIGHT

FISCAL YEAR 1995 BUDGET ESTIMATES

(IN MILLIONS OF REAL YEAR DOLLARS)

	BUDGET PLAN		
	1993	1994	1995
HUMAN SPACE FLIGHT	6,672.0	6,069.7	5,719.9
SPACE STATION	2,162.0	1,937.0	1,889.6
RUSSIAN COOPERATION	79.5	170.8	150.1
SPACE SHUTTLE	3,988.2	3,549.3	3,324.0
PAYLOAD AND UTILIZATION OPERATIONS	442.3	412.6	356.2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

Human Space Flight

For necessary expenses, not otherwise provided for, the conduct and support of human space flight research and development activities, including research; development; operations; services; maintenance; construction, repair, rehabilitation, and modification of real and personal property; acquisition or condemnation of real property, as authorized by law; space flight, spacecraft control and communications activities including operations, production, and services; and purchase, lease, charter, maintenance, and operation of mission and administrative aircraft; $5,719,900,000 to remain available until September 30, 1996: Provided, That amounts appropriated under this heading shall not be subject to the requirements set forth in section 9(e)–(r) of the Small Business Act, as amended (15 U.S.C. 638(e)–(r)), and any related requirements, including such requirements enacted in Public Law 102–564.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUMAN SPACE FLIGHT

REIMBURSABLE SUMMARY

(IN MILLIONS OF REAL YEAR DOLLARS)

	BUDGET PLAN		
	1993	1994	1995
HUMAN SPACE FLIGHT	170.5	107.2	103.9
SPACE STATION	1.2	2.0	2.0
SPACE SHUTTLE	114.8	34.2	25.9
PAYLOAD UTILIZATION AND OPERATIONS	54.5	71.0	76.0

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

FISCAL YEAR 1995 ESTIMATES
DISTRIBUTION OF HUMAN SPACE FLIGHT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Space Sta Program Office	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Goddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA HQ
Space Station	1993	2,162,000	942,100	0	108,100	454,000	0	0	1,500	900	3,100	364,000	288,300
	1994	1,937,000	388,600	1,154,700	69,800	181,100	0	0	0	0	0	110,200	32,600
	1995	1,889,600	431,000	1,213,000	155,000	68,600	0	0	0	0	0	7,000	15,000
Russian Cooperation	1993	79,500	78,500	0	0	1,000	0	0	0	0	0	0	0
	1994	170,800	63,500	100,000	0	7,300	0	0	0	0	0	0	0
	1995	150,100	30,600	100,000	0	19,500	0	0	0	0	0	0	0
Payload and Util Oper	1993	442,300	131,800	0	150,000	124,100	6,500	14,400	0	0	300	200	15,000
	1994	412,600	121,900	0	120,800	131,800	2,400	8,900	100	0	300	100	26,300
	1995	356,200	103,800	0	98,700	136,000	1,800	9,800	0	0	0	0	6,100
Space Shuttle	1993	3,988,200	1,177,000	0	992,100	1,737,500	34,500	0	0	6,300	0	0	40,800
	1994	3,549,300	1,034,900	0	910,900	1,523,500	25,000	0	0	5,700	0	0	49,300
	1995	3,324,000	889,000	0	852,900	1,505,400	20,800	0	0	6,100	0	0	49,800
TOTAL BUDGET PLAN	1993	6,672,000	2,329,400	0	1,250,200	2,316,600	41,000	14,400	1,500	7,200	3,400	364,200	344,100
	1994	6,069,700	1,608,900	1,254,700	1,101,500	1,843,700	27,400	8,900	100	5,700	300	110,300	108,200
	1995	5,719,900	1,454,400	1,313,000	1,106,600	1,729,500	22,600	9,800	0	6,100	0	7,000	70,900

HUMAN SPACE FLIGHT

FISCAL YEAR 1995 ESTIMATES

OFFICE OF SPACE FLIGHT

SPACE STATION

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1993	FY 1994	FY 1995	Page Number
		(Thousands of dollars)		
Development	2,125,000	1,911,000	1,662,000	HSF 1-4
Utilization support	30,000	21,000	96,600	HSF 1-8
Operations	--	--	131,000	HSF 1-10
Assured crew return vehicle	7,000	5,000	--	
Total	2,162,000	1,937,000	1,889,600	

Distribution of Program Amount by Installation

	FY 1993	FY 1994	FY 1995
Johnson Space Center	942,100	388,600	431,000
Space Station Program Office	--	1,154,700	1,213,000
Kennedy Space Center	108,100	69,800	155,000
Marshall Space Flight Center	454,000	181,100	68,600
Langley Research Center	3,100	--	--
Lewis Research Center	364,000	110,200	7,000
Ames Research Center	900	--	--
Jet Propulsion Laboratory	1,500	--	--
Headquarters	288,300	32,600	15,000
Total	2,162,000	1,937,000	1,889,600

OBJECTIVES AND JUSTIFICATION

Development of the United States (U.S.) permanently inhabited Space Station, as directed by President Clinton in 1993, is essential to preserving U.S. preeminence in space-based science, technology and human space flight. The Space Station is our opportunity to provide a truly international vehicle that will enable nations to work together to perform scientific and technological investigations, encourage commercial use of space, and gain direct experience in long-term human operations in space and knowledge essential to future space exploration. The Space Station provides a unique capability to study the effects on the human body while in space for an extended period of time. With this knowledge, countermeasures can be developed and used on future missions as we continue to explore our universe. Medical gains in life sciences will impact the health of all humans on Earth. A prolonged microgravity environment on Space Station allows the achievements in materials science that have been gained on Shuttle, including the development of protein crystals, to be expanded on to help discover the benefits that scientists and researchers have hypothesized for years.

The Space Station will be unique because it provides the U.S. with a permanent outpost in space. The schedule for the newly redesigned, international space station emphasizes an early human tended capability that provides an advanced research laboratory used by international crews for extended durations. Therefore, very early into the program, the Space Station will provide enormous benefits to stimulate new technologies, enhance industrial competitiveness, further commercial space enterprises, and add greatly to the storehouse of scientific knowledge. The program completed the Systems Requirements Review in December 1993. This was a programmatic and technical review which determined that the current configuration meets the requirements specified in the Alpha Program Implementation Plan as approved by President Clinton. This review will be followed by the Systems Design Review (SDR) in March 1994. The SDR is a more detailed review in which the objective is to review more highly refined system designs and validate that those designs meet the requirements.

The Space Station's international aspect was initiated in 1984 with invitations for the full participation of other nations. President Clinton has expanded the international scope of the Space Station dramatically by forming a cooperation with the Russian Space Agency (RSA). Station team members include NASA, RSA, Canada, the European Space Agency (ESA), and Japan. An international cooperation between partners will ensure compatible development of interfacing elements. The Canadian government will develop a mobile servicing system, ESA will include a pressurized module, and the Japanese government has agreed to develop a

pressurized laboratory module. In the redesigned Space Station configuration, the Russian Mir Space Station will play an integral role. In accordance with the terms of the agreements, the U.S. and the international partners will share the total available resources and the common costs for operations. This unprecedented level of international cooperation could also serve as a model for cooperative activities in future space projects and enhance the feasibility of advanced initiatives.

The current Space Station is the culmination of the work begun a year ago to redesign the Space Station to be more efficient and effective in response to lower projections for the Agency budget and increased emphasis on other programs, such as science and aeronautics. Human presence in space is one of NASA's top priorities, and the redesigned Space Station has met the Presidents goal to reduce program costs while still providing significant research capabilities. An entirely new management approach has been implemented, in which a single contractor (Boeing) has been given total prime contractor responsibilities. The other previous prime contractors (McDonnell Douglas and Rocketdyne) and other support contractors are in the process of being novated to Boeing. This will produce clearer lines of authority and greater accountability. The program management has been relocated to the Space Station Program Office (SSPO) in Houston and has been streamlined and structured around integrated product teams with responsibility for bringing the systems and elements into integrated launch packages. Headquarters management has been merged with the Space Shuttle management organization and project management organizations at the various centers have been eliminated. Efficiencies have been gained through these program management improvements as well as through design changes, a simplified integration effort, and a new partnership with the Russians.

The Space Station budget has been restructured to reflect changes in management responsibilities. Transportation support by the Shuttle program, encompassing docking, airlock and extravehicular activity (EVA) systems as well as Shuttle integration support, has been added to the development funding. Similarly, construction of program-specific facilities are now included under development.

Assembly of the Space Station will commence in 1997 at an inclination of 51.6 degrees in order to fully utilize Russian as well as U.S. and partner capabilities. The Station will support human-tended operations and evolve to a permanent human presence and have full operational and research capability. After completion in 2002, the Station is designed to have an operational lifetime of approximately ten years.

BASIS OF FY 1995 FUNDING REQUIREMENT

SPACE STATION DEVELOPMENT

	FY 1993	FY 1994	FY 1995	Page Number
		(Thousands of dollars)		
Flight hardware	2,085,500	1,642,400	1,127,000	
Test, manufacturing and assembly	--	87,600	117,000	
Operations capability and construction	--	151,000	257,800	
Transportation support	25,700	30,000	100,000	
Flight technology demonstrations	--	--	40,000	
Subtotal	2,111,200	1,911,000	1,641,800	
Operations capability and construction	13,800	--	20,200	
Space station processing facility - CoF	12,000	--	--	
Payload operations and integration center modifications - CoF	1,800	--	--	
Neutral buoyancy laboratory - CoF	--	--	20,200	CF 1-1
Total	2,125,00	1,911,000	1,662,000	

OBJECTIVES AND STATUS

Space Station elements will be provided by the U.S. and its international partners. The U.S. elements include two nodes, a laboratory module, truss segments, three photovoltaic arrays, a mini pressurized logistic module, a habitation module, a pressurized mating adaptor, a cupola and an unpressurized logistics carrier. Joint U.S./Russian components include the airlock, energy block, two Soyuz Assured Crew Rescue Vehicle (ACRVs), batteries, solar dynamic modules and additional photovoltaic arrays. The U.S. and Russia have agreed to a three-phased, cooperative effort to ultimately assemble an international Space Station. Phase One is intended to enhance and modify the Russian Mir and study the systems and integration effort required to create the Space Station. Components come together during the second and third program phases for integration, launch, and assembly.

Phase One combines the Shuttle-Mir program with additional Shuttle flights to Mir and U.S. crews aboard Mir, which will provide valuable experience and test data that will greatly reduce technical risks associated with the construction and operation of the international Space Station and provide early opportunities for extended scientific and research activities. Mir capabilities will be enhanced by replacing solar arrays

and adding two Russian modules (Spektr and Priroda) to support U.S. and Russian science and research experiments.

Phase Two combines U.S. with Russian hardware to create a totally new, advanced orbital research facility with early human-tended capability. Five Russian and five U.S. launches will result in a facility that will significantly expand and enlarge the scientific and research activities initiated in Phase One and will form the core around which the international Space Station will be constructed. Power available will total 20.5 Kw from a combination of jointly developed photovoltaic arrays and arrays on the service module and energy block vehicles. Phase Two also develops systems capabilities, including modifications to the Russian FGB Energy Block and Service Module to incorporate a U.S. S-Band communications system, a NH_3 distribution system, a 120 volt direct current power system and distribution to U.S. elements, and distribution of O_2 and N_2 to U.S. elements. Phase Two also includes the docking systems and studies to define a Soyuz ACRV, a Science Power Platform, and the Environmental Control and Life Support System (ECLSS).

Phase Three completes construction. The Station will support a permanent human presence and have full operational and research capability. During this phase, power availability is incrementally increased to 110 Kw by adding power modules. Assembly is completed by completing the truss, adding the U.S. habitation module, completing all distributed systems architectures, adding the station robotics system and integrating the international partner elements. After completion, the Station will have an operational lifetime of approximately ten years.

BASIS OF FY 1995 ESTIMATE

The first American flight launches Node 1, a pressurized volume which contains four radial and two axial berthing ports. The node will be launched with two Pressurized Mating Adapters (PMAs) attached and will serve as the docking location for the delivery of the U.S. Laboratory Module and the pressurized logistics module. Node 2 with an attached cupola is manifested in the second phase of assembly. The final U.S. pressurized volume is the Habitation Module which will contain the galley, ward room, waste management, water processing and other crew support functions necessary for human operations. All U.S. pressurized volumes are developed by Boeing Defense and Space Group, Missiles and Space Division, which has been given the prime contractor responsibility, including integration.

As a subcontractor to Boeing, McDonnell Douglas will develop and build the truss segments that separate Station elements and house essential systems, including central power distribution, thermal distribution and attitude control equipment. Radiators, communications antennas, photovoltaic (PV) elements and the Space Station Robotics Manipulator System are also mounted to truss segments.

The power system, essential to the Station's housekeeping operations and scientific payloads, will be built by Rocketdyne Division, Rockwell International, in a subcontracted effort to Boeing. Three PV elements,

containing a mast, alpha joint, radiator, arrays and associated power storage and conditioning elements make up the power system.

The flight hardware funding also provides for the integration activities and tasks accomplished by Boeing, the prime contractor.

The development program also includes test, manufacturing and assembly support for critical center activities and institutional support. Test capabilities, the provision of government furnished equipment (GFE), and engineering analysis provide in-line products to support the work of the prime contractor, its major subcontractors and NASA system engineering and integration efforts.

Operations capability provides the development of a set of facilities, systems and capabilities to conduct the operations of the Space Station. The work will be performed at the Kennedy Space Center (KSC) and the Johnson Space Center (JSC). The KSC will develop launch site operations capabilities for conducting prelaunch and post-landing ground operations. The JSC will develop space systems operation capabilities for conducting training and on-orbit operations control of the Space Station. Construction of the Neutral Buoyancy Laboratory (NBL) at JSC will provide the capability for Space Station crew training to support a March 1997 training need date. Requirements for simultaneous extravehicular activity (EVA) training (up to nine crews at a time) and larger volume for time critical EVA tasks has dictated the NBL requirement (see Construction of Facilities narrative for detail).

The redesigned Space Station emphasizes multicenter and multiprogram cooperation. At JSC, a consolidated approach between primarily Space Shuttle and Space Station will minimize, if not prevent, duplicated effort and costs for command and control and training. Crew training will be based on a detailed risk analysis to concentrate on probability to determine the optimum failure response training profile. Therefore, training will be knowledge- and proficiency-based rather than driven by timeline and detailed procedures rehearsal. At KSC, ground processing will be performed by a greater number of civil servants and investments in facilities will be limited. The redesigned Space Station will make efficient use of available personnel from other programs.

Transportation support provides those activities which are required to mate and integrate the Space Shuttle and Space Station systems. This budget line supports development and procurement of two external airlocks, and upgrade of a third airlock to full system capability, which are required both for docking the Space Shuttle with the Russian Mir and for use with the Space Station.

Other items in this budget include: the Remote Manipulator System (RMS) and Shuttle Mission Training Facility upgrades; development of a UHF communications system and a laser sensor; procurement of a fifth cryo-tank set and an Operational Space Vision System; procurement of three docking mechanisms and Space

Station docking rings; EVA/extravehicular mobility units (EMU) services and hardware; and integration costs to provide analyses and model development.

Space Station technology and system validation funding requirements include flight technology demonstrations in areas of joint NASA/RSA development that pose a level of technical or programmatic risk, warranting additional verification. Risk areas include life support, the data processing system, automatic rendezvous and docking, vibration isolation in a microgravity environment, assembly and maintenance, loads and dynamics, contamination, radiation environment, and micrometeoroid/orbital debris. In addition, funding is provided for operational techniques development for procedures, utilizing the Shuttle flights to the current Russian Mir, that will benefit the future operational phases of the Space Station program.

BASIS OF FY 1995 FUNDING REQUIREMENT

UTILIZATION SUPPORT

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
User support....................................	30,000	21,000	96,600

OBJECTIVES AND STATUS

User support provides for the development of facilities, systems and capabilities for user operations and the conduct of user operations. The utilization of Space Station must be integrated across NASA centers and the international partners. Streamlined and responsive payload operations support to users will be provided through one research and science control facility.

BASIS OF FY 1995 ESTIMATE

Consolidated utilization includes development of a payload operations integration capability and the Payload Training Complex as well as extensive payload mission planning, analytical integration, and the Payload Data Servicing System (PDSS). The Marshall Space Flight Center's (MSFC's) unique express rack program provides an efficient payload integration capability for smaller payloads that require a limited amount of resources. User support also includes Science and Utilization Management (SUM) that provides outreach, express pallet program and support equipment. Laboratory support equipment includes the freezers, tools, storage, microscope system, refrigerated centrifuge, glove boxes and other equipment to support payload operations. The KSC, in support of the users, will develop a capability to process and verify the payloads prior to flight.

User operations encompasses the payload functions from the initial definition of the payload for flight through the onboard operation and return of the data to the user. Funding is provided for payload planning, development of operations documentation, training of the flight and ground teams and the execution of each mission to meet the needs of the users.

For the redesigned Space Station, the payload integration process has been streamlined and shortened significantly. Standardized payload accommodations and an express rack concept have been adopted to allow for later payload manifesting. Real-time support has also been reduced, based on a relaxed planning concept that allows for activity scheduling during the mission.

BASIS OF FY 1995 FUNDING REQUIREMENT

ASSURED CREW RETURN VEHICLE

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Assured crew return vehicle.....................	7,000	5,000	--

OBJECTIVES AND STATUS

The redesigned Space Station will use an Assured Crew Return Vehicle (ACRV) based on a Soyuz vehicle and launched on a Russian booster for rescue and crew rotation. The Soyuz ACRV is a Russian element of the Space Station, and currently requires no U.S. funding in 1995.

BASIS OF FY 1995 FUNDING REQUIREMENT

SPACE STATION OPERATIONS

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Vehicle operations............................	--	--	54,000
Ground and transportation operations...........	--	--	77,000
Total...................................	--	--	131,000

OBJECTIVES AND STATUS

Space Station operations provides for the sustained operations of the Space Station as well as the ground and transportation operations required to support the vehicle. Planning for operations is an integral part of the station design and development program, and simplified and affordable operations was a major objective in the recent redesign process. The infrastructure developed for the Shuttle and the experience derived from the Shuttle-Mir program are necessary for efficient and effective operations of the station. The various elements of development will transition, over time, to the operations program and funding in FY 1995 for long-lead components and operations preparation necessary to support the start of assembly in 1997.

BASIS OF FY 1995 ESTIMATE

Vehicle operations is the budget element for: (a) post-development systems engineering and integration necessary to sustain the specification performance and reliability of Space Station systems; (b) logistics support for flight hardware and launch site ground support equipment, the near-term requirement which drives the FY 1995 funding requirement because long-lead flight spares acquisition must begin to support early flight hardware; and (c) configuration management and any associated procurement activity.

The normal sustaining engineering function for the redesigned Space Station will be performed by a small cadre of civil service system experts located at each development center, as opposed to carryover of prime contractor and subcontractor personnel.

Flight software sustaining engineering will consist of a limited code maintenance capability. This will allow all flight software to be handled under a single contract.

Ground operations includes command and control, logistics, training, and ground processing.

A unified command and control center for the Space Station will be composed of the Mission Control Center (MCC)-Houston and the Mission Control Center (MCC)-Kaliningrad. The MCC-Houston will be the prime site for the planning and execution of integrated system operations of the Space Station, with exclusive command and control authority. Communication links from both Moscow and Houston will support control activities, using the Tracking and Data Relay Satellite (TDRS) system.

The U.S. and Russia are individually responsible for those logistic requirements which are unique to their elements on the Station. Logistics requirements which support the ability to use and operate the Station will be shared. Maintenance and repair costs have been minimized on the redesigned Space Station by accepting longer repair timespans, establishing a single maintenance and repair capability at the Kennedy Space Center (KSC) and using original equipment manufacturers or other certified industry repair resources.

Flight controllers will be trained to operate the Station as a single integrated vehicle, with full systems capability in the training environment. Crew members will be trained in Station systems, operations, and other activities expected during a mission. Part-task and full hardware mockups and simulators will be used to provide adequate training for the crew prior to flight. Integrated training, consolidation of training facilities and the concept of proficiency based learning will increase the efficiency of the overall training effort.

Once the flight cargo elements have undergone acceptance testing at the development location, they will be transported to KSC for ground processing. This includes integrated testing, interface verification, servicing, launch activities and experiment-to-rack physical integration. Because Station is a ten-year program, no major upgrades to facility systems and equipment are being planned.

HUMAN SPACE FLIGHT

FISCAL YEAR 1995 ESTIMATES

OFFICE OF SPACE FLIGHT

RUSSIAN COOPERATION

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Russian space agency contract support	--	100,000	100,000
Mir support	79,500	70,800	50,100
Total	79,500	170,800	150,100
Distribution of Program Amount by Installation			
Johnson Space Center	78,500	63,500	30,600
Space Station Program Office	--	100,000	100,000
Marshall Space Flight Center	1,000	7,300	19,500
Total	79,500	170,800	150,100

OBJECTIVES AND STATUS

The U.S. and the Russian Federation have agreed to enter into an enhanced cooperative space program, consisting of a number of inter-related projects in several phases which are intended to result in the enhancement of Mir-1 operational capabilities, joint space flights, and joint activities leading to Russian participation in the design, development, operation, and utilization of an international Space Station. This relationship between the U.S. and Russian space agencies will advance their national space programs and benefit their respective national aerospace industries.

The plan is composed of three phases, parts of which are conducted in parallel. Phase One expands the joint participation by U.S. and Russian crews in Mir and Shuttle operations. This expanded program utilizes the unique capabilities of the Shuttle and Mir programs and provides for the potential of up to ten flights to the Mir, including U.S. crew stays aboard Mir. This program will provide valuable experience and test data that will greatly reduce technical risks associated with the construction and operation of the international Space Station and provide early opportunities for extended scientific and research activities. Mir capabilities will be enhanced by contributions from both the U.S. and Russia. The Shuttle will bring new solar arrays (to be built by the Russians, utilizing solar cells provided by the U.S.) to replace existing

arrays on Mir. Russia will add Spektr and Priroda modules to Mir, equipped with U.S. and Russian scientific hardware to support science and research experiments.

Phase Two combines U.S. and Russian hardware to create a totally new, advanced orbital research facility with early human-tended capability. This facility will significantly expand the scientific and research activities initiated in Phase One, and will form the core around which the international Space Station will be constructed. Phase Two also develops the systems capabilities, support, and other infrastructure to complete the international Space Station.

Phase Three will complete construction, enabling the station to support a permanent human presence with full operational and research capability.

BASIS OF FY 1995 ESTIMATE

Russian Support - The Russian Space Agency (RSA) has agreed to furnish supplies and/or services in a firm-fixed-price contractual arrangement with NASA. The purpose of the contract is to enhance Mir-1 operational capabilities, perform joint space flights, and conduct joint activities to design, develop, operate and utilize the international Space Station.

Phase One supplies and/or services provided by RSA include management activities, Mir lifetime extension, Mir capabilities expansion, docking hardware, and mission support for both long-duration and short-term missions. Management activities include project documentation and design, program management, subcontract management, and travel. Mir lifetime extension includes system requirements planning, communication and control systems analyses and upgrades, ground control facilities, thermal control documentation and requirements definition, environmentally-closed life support system (ECLSS) upgrades, power supply system upgrades, propulsion systems documentation and initial design and test, and elements of construction and mechanisms. Mir capabilities expand with the introduction of the Spektr and Priroda modules, to be attached to the Mir for scientific use by Russia and the U.S.

Phase Two supplies and/or services provided by RSA include management; advanced technology; international Space Station elements (Phase B); Assured Crew Return Vehicle (ACRV) Phase B modification design, documentation and long-lead hardware; and a study to evaluate the use of the Proton launch vehicle with Space Tug as a back-up to Shuttle. Advanced technology includes joint development of ECLSS upgrades and a study to develop a common space suit. International Space Station elements include requirements definition of a joint airlock and androgynous peripheral docking system (APDS) hardware, service module modifications, energy block modifications, and a study on a scientific power platform.

Mir Support - Mir Support includes the NASA effort involved with Shuttle and Spacelab requirements in support of the Mir program.

The FY 1995 funding is provided to complete the mission requirements for the STS-71 mission which docks the Atlantis (OV-104) with the Russian Mir Space Station in June 1995. The objectives of this mission are to demonstrate the docking concept with the Shuttle before potential use on the Space Station; examine the potential use of the Russian docking mechanism for the international Space Station; enhance our understanding of long-duration operations; and obtain life science and microgravity research benefits from long-duration experimentation. In addition, this mission will deliver two Russian cosmonauts to Mir and return to Earth three Mir crew members.

The Mir follow-on flights will utilize current program hardware which was built and procured for the Mir-1 flight (STS-71). The follow-on flights require funding to extend the current mission certification of the docking mechanism and mission support and integration. These flights will be performed over a two-year period and will enhance our life sciences and microgravity research capabilities. Payloads, flight demonstrations and experiments for these missions are funded under the Life and Microgravity Sciences and Applications and Space Station programs.

The FY 1995 funding also supports operational Spacelab requirements associated with the Mir flights including mission planning, mission integration and flight and ground operations. This includes integration of the flight hardware and software, mission independent crew training, system operations support, payload operations control support, payload processing, logistical support and sustaining support. Funding will provide for the processing of a pressurized Spacelab long module to fly life and microgravity science experiments to dock with the Russian Mir. In addition, funding will continue to support the processing of follow-on missions which include a minimum of two unpressurized pallet missions and three additional pressurized Spacelab module missions to be launched in FY 1995-FY 1997. In addition to the life science and microgravity payloads, Space Station flight technology demonstrations are planned for these flights.

HUMAN SPACE FLIGHT

FISCAL YEAR 1995 ESTIMATES

OFFICE OF SPACE FLIGHT | **SPACE SHUTTLE**

	FY 1993	FY 1994	FY 1995	Page Number
		(Thousands of dollars)		
Shuttle operations	2,857,200	2,570,600	2,420,100	HSF 3-3
Safety and performance upgrades	1,131,000	978,700	903,900	HSF 3-8
Total	3,988,200	3,549,300	3,324,000	
Distribution of Program Amount by Installation				
Johnson Space Center	1,177,000	1,034,900	889,000	
Kennedy Space Center	992,100	910,900	852,900	
Marshall Space Flight Center	1,737,500	1,523,500	1,505,400	
Stennis Space Center	34,500	25,000	20,800	
Ames Research Center	6,300	5,700	6,100	
Headquarters	40,800	49,300	49,800	
Total	3,988,200	3,549,300	3,324,000	

OBJECTIVES AND JUSTIFICATION

The primary program objective of the Space Shuttle is to support NASA launch requirements while maintaining the essential program focus on safety and mission success demonstrated since returning the Shuttle to flight. Because of its unique capabilities, the Shuttle remains a key element of America's space program. The Shuttle is the first reusable space vehicle and can be configured to carry many different types of space apparatus, spacecraft, and scientific experiments. In addition to transporting materials, equipment, and spacecraft to orbit, the Shuttle offers unique capabilities such as retrieving payloads from orbit for re-use, servicing and repairing satellites and observatories in space as was demonstrated with the successful repair of the Hubble Space Telescope, safely transporting humans to and from space and operating and returning space laboratories.

Strategically, the Shuttle program strives to maintain the capability to safely fly eight flights every year. In order to improve safety margins of the Shuttle by a factor of two, as well as provide performance and capability enhancements, the program is implementing modifications such as upgrades to the main engine and development of a super lightweight external tank that will provide increased payload lift capability. However, the program is acutely aware that providing reliable access to space must be more cost effective in order to exploit these capabilities fully. As a result, major cost reduction measures which have been implemented since FY 1992 will continue.

The revised NASA budget structure includes the Space Shuttle program within the Human Space Flight appropriation with two major components: Space Shuttle Operations and Safety and Performance Upgrades. Shuttle operations supports the launch of NASA missions and is the primary program in which efficiencies have been implemented and thereby significantly reducing the cost of flying the Shuttle. When measured from the program's FY 1992 actual budget, a 24% reduction will be realized. The Shuttle launch schedule plans for a maximum flight rate of eight per year in FY 1994 through FY 1999. Safety and performance upgrades provides for modification and improvement to the flight elements and ground facilities, and permits expansion of safety and operating margins and enhancement of Shuttle capabilities as well as the replacement of obsolescent systems. This budget now includes funding for facilities related to the Space Shuttle which were previously part of NASA's Construction of Facilities appropriation. In FY 1994 and FY 1995, facilities at the Johnson Space Center, the Kennedy Space Center, and the Stennis Space Center will be modified to improve their performance and, in some cases, will be refurbished and restored to acceptable conditions after over ten years of use.

BASIS OF FY 1995 FUNDING REQUIREMENT

SHUTTLE OPERATIONS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Orbiter	477,000	364,100	292,800
System integration	200,600	211,200	190,500
External tank	300,200	305,300	379,600
Space shuttle main engine	239,900	191,800	144,400
Redesigned solid rocket motor	409,400	368,900	373,100
Solid rocket booster	172,000	156,400	144,900
Launch and landing operations	697,100	650,100	596,400
Mission and crew operations	361,000	322,800	298,400
Total	2,857,200	2,570,600	2,420,100

OBJECTIVES AND STATUS

Shuttle Operations provides launch services to NASA payloads as well as to other government agencies and international users. Shuttle operations is manifested to a planned rate of eight flights per year. In FY 1994, the Space Shuttle successfully completed the Hubble Space Telescope (HST) mission, the second Spacelab mission dedicated to the life sciences, and will have flown six additional missions by September 1994. Other major payloads to be flown in FY 1994 include: materials processing in a microgravity environment for both U.S. and international customers; experiments involving molecular and chemical growth of compound semi-conductors in the Wake Shield Facility; Spacehab payloads for commercial customers; Space Radar Laboratory flights; and over 30 middeck payloads. Also, the first of the cooperative missions with the Russians will be initiated when the Russian cosmonaut accompanies the Shuttle on STS-60 in February.

The Space Shuttle has demonstrated a broad range of capabilities including deployment of spacecraft and their upper stages, satellite repairs, satellite retrieval, operations using the Remote Manipulator System, integral scientific experimentation using Shuttle and Spacelab systems, and extravehicular activity (EVA) operations. These capabilities provide a unique national resource that enhances the scientific reward of many payloads. In FY 1994 the Shuttle program demonstrated its unique capability when it successfully repaired the HST in December 1993. In FY 1994 the Shuttle will fly eight flights with a wide variety of scientific payloads including two microgravity flights, two space radar lab flights, and the second flight of the commercial Spacehab module. These flights will also carry a multitude of secondary payloads. In addition there will be two extended duration flights of thirteen to sixteen days on Columbia (OV-102).

The Space Shuttle program aggressively continues its plans to significantly reduce the cost of operations. Initiated in FY 1992, this cost reduction effort capitalizes on program efficiencies and relies on specific content reductions to reach its goals. Both Shuttle project offices and Shuttle contractors have been challenged to meet reduced budget targets.

As in the past, Shuttle operations requirements are funded through a combination of funds received from Congressional appropriations and reimbursements received from customers whose payloads are manifested on the Shuttle. The reimbursements are applied consistent with the receipt of funds and mission lead times, and are subject to change as manifests are revised. In FY 1994 planned reimbursements total $9 million.

The Orbiter program element consists of the following items and activities: (1) Orbiter spares for the replenishment of line replacement units (LRUs) and shop replacement units (SRUs) along with the manpower required to support the orbiter logistics program; (2) production of external tank (ET) disconnect hardware; (3) flight crew equipment processing as well as flight crew equipment spares and maintenance including hardware to support Shuttle EVA; and (4) various orbiter support hardware items such as pyrotechnic initiated controllers (PICS), NASA standard initiators (NSIs), and overhauls and repairs associated with the Remote Manipulator System (RMS). The sustaining engineering associated with the orbiter vehicles is now included in this budget element.

System integration captures those elements managed by the Space Shuttle Program Office, including payload integration into the Shuttle and systems integration of the flight hardware elements through all phases of flight. Payload integration provides for the engineering analysis needed to ensure that various payloads can be assembled and integrated to form a viable and safe cargo for each Shuttle mission. Systems integration includes the necessary mechanical, aerodynamic, and avionics engineering tasks to ensure that the entire launch vehicle can be safely launched, fly a safe ascent trajectory, achieve planned performance, and descend to a safe landing. In addition, funds are provided for multi-program support at the Johnson Space Center (JSC).

The redesigned solid rocket motor (RSRM) budget includes: (1) purchase of solid rocket propellant and other materials to manufacture motors; (2) necessary manpower to repair and refurbish flown rocket case segments; (3) manpower to assemble individual case segments into casting segments and other production operations including shipment to the launch site; (4) engineering manpower required for flight support and anomaly resolution; and (5) new hardware to support the flight schedule required as a result of attrition.

The production of external tanks involves the following: (1) procurement of materials and components from vendors; (2) manpower at the Government Owned Contractor Operated (GOCO) facility to manufacture tanks; (3) support manpower and other costs to operate the GOCO facility; and (4) sustaining engineering for flight support and anomaly resolution. The program will deliver four tanks in FY 1994. In the past year, the contractor has taken major steps to reduce the manpower and costs needed to deliver this hardware. The

additional material and production costs associated with the super lightweight tank is also included in this budget.

The Space Shuttle main engine (SSME) operations budget provides for overhaul and repair of main engine components, procurement of main engine spare parts, and main engine flight support and anomaly resolution. This budget also includes funding to DoD for DCAS support in the quality assurance and inspection of Shuttle hardware. In addition, funds are provided for transportation and logistics costs in support of SSME flight operations.

The solid rocket booster budget funds: (1) procurement of new hardware and materials needed to support the flight schedule; (2) work at various locations throughout the country for the repair of flown components; (3) manpower at the prime contractor facility for integration of both used and new components into a forward and an aft assembly; and (4) sustaining engineering for flight support.

Launch and landing operations provides for the manpower and materials to process and prepare the Shuttle flight hardware elements for launch as they flow through the processing facilities at the Kennedy Space Center (KSC). Standard processing and preparation of payloads as they are integrated into the orbiter are also funded under this category, as is procurement of liquid propellants and gases for launch and base support. Support to landing operations at KSC, Edwards Air Force Base (EAFB) and contingency sites, as required, is also provided.

Operation of the launch and landing facilities and equipment at the KSC involves refurbishing the orbiter, stacking and mating of the flight hardware elements into a launch vehicle configuration, verifying the launch configuration, and operating the launch processing system prior to lift-off. Launch operations also provides for booster retrieval operations, configuration control, logistics, transportation, and inventory management. This budget also includes other launch support services. The central data subsystem, which supports Shuttle processing as an on-line element of the launch processing system, is maintained and repaired. Shuttle-related data management functions such as work control and test procedures are funded. Equipment, supplies and services are purchased. Operations support functions are provided. Among these support functions are propellant processing, life support systems maintenance, railroad maintenance, pressure vessel certification, Shuttle landing facility upkeep, range support, and equipment modifications.

Mission and crew operations includes a wide variety of pre-flight planning, crew training, operations control activities, flight crew operations support, aircraft maintenance and operations, and life sciences operations support. The planning activities range from the development of operational concepts and techniques to the creation of detailed systems operational procedures and checklists. Tasks include: flight planning; preparing systems and software handbooks; defining flight rules; creating detailed crew activity plans and procedures; updating network system requirements for each flight; and contributing to planning for the selection and operation of Shuttle payloads. Also included are developing, upgrading and

establishing the Control Center Complex (CCC), Integrated Training Facility (ITF), Integrated Planning System (IPS), and the Software Production Facility (SPF). These four facilities integrate the mission operations requirements for both the Space Shuttle and Space Station. Flight planning encompasses flight design, flight analysis, and software activities. Both conceptual and operational flight profiles are designed for each flight, and the designers also help to develop crew training simulations and flight techniques. In addition, the flight designers must develop unique, flight-dependent data for each mission. The data is stored in erasable memories located in the orbiter, ITF Shuttle mission simulators, and CCC computer systems. Mission operations funding also provides for the maintenance and operation of critical mission support facilities including the CCC, ITF, IPS and SPF. Finally, mission operations includes maintenance and operations of aircraft needed for flight training and crew proficiency requirements.

Other support requirements are also provided for in this budget, including engineering tasks at the JSC which support the flight software development and verification. The software activities include development, formulation, and verification of the guidance, targeting, and navigation systems software in the orbiter.

BASIS OF FY 1995 ESTIMATE

The requirements for Shuttle operations are based on supporting the launch of eight Shuttle flights and their associated payloads. Each Shuttle project has been working to a very aggressive cost reduction program resulting from cost targets established by NASA management. These projects will continue to implement cost reductions in FY 1995 as well as the outyears by critically reviewing their current requirements and by exploring new ways of doing business in order to determine the minimum resource level needed to support the manifest without compromising flight safety. The cost of Shuttle operations in FY 1995 is almost 6% less than FY 1994 and represents a significant challenge to the program. Both prime contractor and supporting manpower are being reduced across the program by contract restructuring, utilization of civil service wherever possible, reevaluating processes, consolidating skills and reevaluating training requirements. In order to accommodate reductions of this magnitude, the program is currently examining major structural changes as well as changes to roles and missions.

The orbiter requirements are based on flight rate, maintenance schedules, operational usage, repair times, and lead times to procure new hardware or repair flown hardware. The requirements for system integration are based on the flight rate, specific payloads manifested, and unique launch requirements such as inclination or performance requirements. The first flight to dock with the Russian Mir will be flown in May 1995 at a high inclination orbit. In addition the full capability of an extended duration flight will be demonstrated with a sixteen-day mission to be flown with a U.S. Microgravity Laboratory (USML-2) payload in September 1995.

The requirements for the external tank, solid rocket booster, and redesigned solid rocket motor are based on the flight schedule planned for FY 1995 and the outyears. The budget provides for production of hardware as well as purchase of long-lead hardware based on each project's unique manufacturing leadtime requirements. The external tank production rate is increasing from four to six in FY 1995 to support the flight rate of eight missions, as the current inventory of tanks is being depleted. In addition, funds are provided to purchase materials to produce the super lightweight tank based on utilization of aluminum lithium. The requirements for the main engine are based on operational usage of flight hardware, repair times, and lead times to refurbish flown hardware. Launch and landing operations funding in FY 1995 provides manpower and support services necessary for processing the hardware to launch from the KSC as well as to support landing operations at the KSC and Dryden Flight Research Facility, and contingency sites. This includes manpower to assemble the solid rocket boosters (SRBs), mate the boosters and tanks, process the orbiter, mate the orbiter to the integrated SRBs and external tank, process and checkout integrated flight elements through launch, retrieve and disassemble the SRBs for refurbishment, and support landing of the orbiter. Funding also supports the manpower required for the KSC sustaining engineering, provisioning, logistics, launch processing system operation and maintenance, and maintenance/modification of all other Shuttle-related ground support equipment and facilities including Launch Complex 39. Mission operations primarily supports functions at the JSC to plan for and conduct Shuttle missions from launch to landing. The functions are to maintain and operate all the ground facilities necessary for flight preparation and execution; to train the flight and ground controller crews in all aspects of flight including EVA training; to maintain the proficiency of operational aircraft for training and orbiter ferry requirements; and to provide real-time support to each Shuttle mission.

BASIS OF FY 1995 FUNDING REQUIREMENT

SAFETY AND PERFORMANCE UPGRADES

	FY 1993	FY 1994	FY 1995	Page Number
		(Thousands of dollars)		
Orbiter improvements	235,000	215,500	191,800	
(Multifunction electronic display system)	(19,800)	(33,600)	(56,000)	
(Extended duration orbiter)	(20,400)	(24,100)	(2,900)	
(Long duration orbiter)	(7,400)	(43,000)	(--)	
(Reaction control system direct acting valve)	(--)	(--)	(7,200)	
(Fiber optics - payload bay)	(--)	(12,000)	(17,000)	
(Structural spares)	(35,000)	(5,000)	(--)	
(Other orbiter improvements)	(152,400)	(97,800)	(108,700)	
Space shuttle main engine upgrades	320,300	287,900	380,500	
(Alternate turbopump)	(50,100)	(54,000)	(107,800)	
(Large throat main combustion chamber)	(2,600)	(18,400)	(24,600)	
(Space shuttle main engine health monitoring)	(--)	(--)	(15,000)	
(Other upgrades)	(267,600)	(215,500)	(233,100)	
Solid rocket booster improvements	1,400	23,200	51,600	
Super lightweight tank	--	49,500	80,700	
Launch site equipment upgrades	80,100	81,700	76,100	
(Hardware interface module cards)	(3,000)	(5,600)	(9,200)	
(Cable plant upgrades)	(6,900)	(10,000)	(7,100)	
(Other upgrades)	(70,200)	(66,100)	(59,800)	
Flight operations upgrades	121,100	107,700	110,900	
Advanced solid rocket motor	195,000	179,700	--	
Construction of facilities	178,100	33,500	12,300	CF 1-4 & 1-7
Total	1,131,000	978,700	903,900	

OBJECTIVES AND STATUS

Safety and Performance Upgrades provides for development activities to improve Shuttle safety margins, ensuring the sustained availability of existing capabilities, including replacement of obsolete systems for the long-term viability of the Shuttle program. It also permits limited expansion of Shuttle capabilities when required by specific customer flight requirements. In addition, funding is provided to meet environmental requirements such as replacement of materials or site remediation. These requirements are

established by federal, state, and local laws and regulations. Included in this budget line are: orbiter improvements necessary to support the Space Shuttle, development and testing of the Space Shuttle Main Engine (SSME) to provide for increased flight safety, development of a super lightweight external tank to provide additional payload lift capability, upgrades of equipment at the Kennedy Space Center (KSC), equipment replacement and upgrades at the Johnson Space Center (JSC) to support mission operations, completion of termination activities on the advanced solid rocket motor (ASRM), and construction of facilities which support the Shuttle program.

So that the U.S. can maintain a viable manned transportation capability into the next century, specific program investments are required. The Safety and Performance Upgrades budget provides for the necessary improvements on the Shuttle needed to expand existing safety margins as well as to ensure continued safe and reliable Shuttle operations by replacing obsolete systems whose failure rates are continually increasing. Improved flight turnaround times and reduced operational costs are also benefits of this program. These improvements must necessarily be supplied as individual hardware systems experience problems or when vendors will no longer manufacture or support older components. These requirements are increasing as the Shuttle system ages and safer ways of operating the Space Shuttle become necessary.

The management approval process and vulnerability analyses ensure that improvements are evaluated and approved on a priority basis across the entire Shuttle program. This process includes both the launch vehicle projects (external tank, orbiter, Space Shuttle main engine) as well as supporting systems such as the ground processing and mission support systems.

The schedule for development and installation of orbiter-related improvements is designed to take advantage of the planned intervals when orbiters are scheduled to be taken out of service for structural inspections and modifications. This plan provides for an orderly development and implementation program and minimizes interruption of the flight program.

Orbiter improvements provides for necessary improvements, modification kits, and mission kits that enable the orbiter fleet to satisfy flight requirements. The extended duration orbiter (EDO) development is funded to increase the on-orbit duration from the baseline seven to ten days, enabling the Shuttle to support an increased variety of payload requirements. Orbiter production activities include safety modifications, capability improvements, and the development and installation of necessary hardware, software, and procedural modifications for the orbiters, the Remote Manipulator System (RMS) and the Extravehicular Activity (EVA) capabilities. Work continues on improvements to achieve greater operational capabilities, reduce operational costs, and meet system requirements. In addition, system level engineering analysis tasks will expand safety margins and performance capabilities.

The EDO program provides the necessary capabilities to extend the on-orbit duration from the current baseline of seven to ten days. This capability provides a cryogenic pallet system that can support a

Spacelab-type flight for periods up to sixteen days. The initial pallet development was financed by Rockwell, and funding is provided to complete the commercialization agreement in FY 1994. Logistics items impacted by extended on-orbit operations, such as repair parts for fuel cells, are also included. Columbia is the initial EDO vehicle. The first flight utilizing the pallet was in June 1992 on the United States Microgravity Laboratory (USML-1) mission. The first sixteen-day mission is planned on USML-2 in FY 1995. In 1994, a cryogenic pallet is being fabricated and to provide a capability to extend its on-orbit capability beyond the sixteen-day EDO period, if required. In response to FY 1995 and outyear budget constraints, and due to the earlier availability of the international Space Station, activities associated with the development of the Long-Duration Orbiter (LDO) capability will be terminated. A portion of the LDO funding will be retained, however, to provide for development of the Long-Life Fuel Cell (LLFC). The LLFC is expected to increase the time between overhauls from an experience base of approximately 1500 hours to a design life that approaches 10,000 hours. This LDO subsystem has been retained for continued development due to its contribution to lower logistics and overhaul cost, as well as increased reliability.

The Multifunctional Electronic Display System (MEDS) upgrade will allow replacement of the 1970's display technologies which are embedded in the orbiter cockpit. The current display system, which provides the pilot and commander with vehicle flight control and with the interface to the orbiter data processing system, is a single string electro-mechanical system. This system is proving to be particularly susceptible to life-related failures. The upgrade will provide both a new architecture and the flight equipment to enhance the reliability of the system and will resolve the parts availability problems. The new state-of-the-art display system will bring the orbiter up to current aircraft standards which will have a direct benefit on training of new astronauts while also providing the potential for enhanced information flow during operations. The MEDS upgrade includes the design effort and the production of additional modification kits for the four orbiter vehicles. New ground support hardware has also been designed and will be procured and installed to upgrade the appropriate simulators, test equipment, and laboratories. MEDS consists of two phases. Phase one will incorporate a multi-functional cathode ray tube display system consisting of four display units, four data processors, and two panel assemblies. The first flight utilizing these changes is planned in 1996. Phase two incorporates flight instrumentation and system status meters including additional panel assemblies, display driver units, and other hardware. The first flight incorporating these improvements is planned in 1998.

Systems integration tasks include the continuing development of the Program Compliance and Assurance System (PCAS) which is a comprehensive Shuttle data base that examines failure histories across all the Shuttle elements. Also included are contingency landing and abort analyses to support full utilization of existing orbiter capabilities.

The SSME program provides for continued development and extensive testing of the Space Shuttle main engines. The SSME program strives to improve operating margins by introducing safety, life extension, and producibility enhancements. Program funds include procurement of spare hardware, personnel, and other

support needed to develop and test these enhancements. The SSME program also purchases replacement engines to support the flight and ground test program.

The SSME program also funds development and certification activities to improve safety, reliability, durability, and engine operating margins as well as to make the SSME easier to produce and maintain. The major improvements currently in work are the single-coil heat exchanger, the Phase II+ powerhead, the Alternate Turbopumps (both liquid oxygen (LOX) and fuel), the Large Throat Main Combustion Chamber, and a Health Monitoring System for the SSME. These improvements will effectively double the overall Shuttle safety margins once they are completed.

The single-coil heat exchanger will substantially increase the safety of the engine by eliminating many critical safety risks. The heat exchanger, mounted in the powerhead, uses the hot (800-900° F), hydrogen-rich gas exiting the LOX turbine to convert liquid oxygen to gaseous oxygen for pressurizing the external tank oxygen tank and the pogo suppression system. Even a tiny leak of oxygen into the hot hydrogen gas would rapidly cause destruction of the engine. The single-coil heat exchanger has no welds exposed to the hot gas flow, and has tube walls about three times thicker than in the current design.

The SSME powerhead is the backbone of the engine. It connects the two pre-burners powering the high-pressure turbopumps with the main propellant injector through a hot-gas manifold and contains the heat exchanger as well as the attachment points for the high pressure turbopumps and the main combustion chamber (MCC). The current hot-gas manifold links the main injector to the fuel pre-burner with three ducts and to the oxidizer pre-burner with two ducts. This configuration yields hot gas flows with non-uniform pressures and velocities, as well as large pressure drops, conditions which place high dynamic loads on the main injector elements and reduce engine performance. In addition, the significant pressure drop in hot gas flow in the ducting from the fuel turbine to the main injector places large lateral loads on the sheet metal structure in the high-pressure fuel turbopump. The current powerhead is constructed with a large number of welds, many uninspectable, making it difficult to produce and raising concerns about quality, reliability, durability, and safety. The Phase II+ powerhead addresses the issues with the current design by using a two-duct configuration between the fuel pump and the main injector to significantly improve the hot gas flow characteristics, and by reducing the number of welds by 24%, leaving all remaining welds inspectable. Testing on the Phase II+ powerhead in company with the single-coil heat exchanger began in 1992, with certification testing scheduled to be completed in mid-1995.

The SSME budget funds contractor test and engineering manpower and hardware. The hardware procured includes spare parts for test engines, newly designed components like the two-duct hot-gas manifold and the single-coil heat exchanger and new engines to replace those in the test fleet that reach their life limits. The SSME project budget also includes NASA supporting engineering at the Marshall Space Flight Center (MSFC), support contractor work at the Stennis Space Center (SSC), and test propellants at MSFC and SSC.

The most challenging and potentially troublesome components of the SSME are the high pressure turbopumps. Engine system requirements result in pump discharge pressure levels from 6000 to 8000 psi and turbine inlet temperatures in excess of 2000°. In reviewing the most critical items on the SSME that could lead to a catastrophic failure, fourteen of the top 25 are associated with these turbopumps. Moreover, the turbopumps are difficult to manufacture and require extensive inspections and frequent removal for overhaul and retest. Over the years, the current turbopumps have been the source of several flight delays and many ground test failures. While remedies have been sought to address the continuing problems with the turbopumps, management concluded in 1985, and independent outside technical review panels agreed, that a complete redesign was necessary. This new design resulted in the alternate turbopump (ATP) program.

The ATP design incorporates state-of-the-art technology intended to address the shortcomings of the current SSME high-pressure turbopumps. The pumps are precision cast with fewer parts, stiffer shafts, and better bearings than the current pumps. The number of welds have been reduced from 769 to 7. All uninspectable welds have been eliminated. With these improvements, the pumps will provide increased supportability, greater safety margins, and a longer operating life than the current pumps.

A number of technical problems have plagued the liquid oxygen (LOX) pump, including turbine inlet cracking, turbine bellows cracking, high synchronous vibration anomalies and ball bearing wear. Design improvements have been implemented and successfully demonstrated. These problems have required numerous pump rebuilds and engine testing to resolve. The ATP LOX pump testing has accumulated over 40,000 seconds of development time in engine systems testing at the SSC. The critical design review has been successfully completed and certification testing will begin early in 1994. Testing has included nominal mission duration and power level, as well as abort duration (fourteen minutes) and 109% power level. Consistent with direction contained in the House Report 102-226, NASA assessed the merits of continuing development of the Alternate Fuel Pump. Development activities on the fuel pump were suspended so that efforts could be focused on the LOX pump. Now that the LOX pump efforts have been successful, NASA is prepared to report results of the effort to Congress and seek approval to resume development efforts on the fuel pump. Based on the current schedule, assuming Congressional approval, this resumption would occur in FY 1994. First flight using the LOX pump is planned for June 1995 and the first flight using the fuel pump is scheduled in FY 1998 (along with the Large Throat Main Combustion Chamber).

The SSME's staged combustion cycle and high main combustion chamber pressure (~3000 psi) result in extremely stressful internal operating conditions, such as high turbine discharge pressures and temperatures, and high turbopump shaft speeds. In order to alleviate these conditions, the Large Throat Main Combustion Chamber (LTMCC) was initiated in FY 1993. The LTMCC differs from the current Main Combustion Chamber (MCC) in several ways. The throat diameter is increased 11% which lowers the chamber pressure by 9%. The contour of the chamber also allows an increase in the number of coolant channels, thereby reducing the operating temperature of the hot wall inside the MCC and increasing the MCC's life as well as reducing the potential for pin hole leaks and coolant channel cracks. While use of the LTMCC configuration at 104% of its rated

power level (RPL) is equivalent to using the current MCC at 100% RPL, the operating conditions discussed above are lowered by as much as 10% in some cases. This improvement, coupled with ongoing SSME upgrades, is expected to improve the Shuttle safety margins by a factor of two. The development program consists of four units for testing purposes along with the purchase of the necessary units for fleet retrofit. The LTMCC program also includes the required modifications to the other elements of the SSME as well as incremental support required by the test program. A first flight utilizing the new LTMCC is planned for FY 1998.

A health monitoring system for the SSME is proposed for initiation in FY 1995 to improve both safety and launch reliability by replacing obsolete sensors as well as providing a more integrated system to monitor engine performance and health. The basic strategy is to minimize the potential for an on-pad or inflight abort resulting from a single instrument or control component failure. Engine health monitoring will allow the controller software to distinguish a real engine performance degradation from a sensor or control monitoring anomaly. Changes being evaluated for the Block IIE controller include single actuator switchover, response rate and dynamic sensor qualification, dynamic engine modeling allowing "smart redlines", adaptive control capability, and radiation hardened memory.

Solid rocket booster (SRB) improvements include static test firing of redesigned solid rocket motors (RSRM) to certify new subsystems for flight, to obtain engineering data on motor performance, and to reclaim reusable hardware needed for the flight program. In addition funding is provided to develop and certify for flight asbestos-free insulation by 1997. In the wake of the canceled ASRM, other environmental improvements will also be required by the RSRM program. This program funds the establishment of a new nozzle fabrication and refurbishment capability at Iuka, Mississippi (Yellow Creek) to utilize new and modern facilities made available by the termination of the ASRM project. A ninety-day study is being performed in early 1994 by the MSFC and Thiokol, Inc. to establish the specifics of the alternate uses of the infrastructure at Yellow Creek. This study will consider modifications to facilities, equipment, and other requirements as well as a potential capital investment by Thiokol in equipment and facilities. Congress will receive a full description of the study results, the proposed agreement, and a more detailed outline of the legal relationship between the government and the contractor prior to proceeding. This proposal will provide for the upgrade of the RSRM manufacturing process, provide for a return on the government's investment in the Yellow Creek site, and mitigate the economic impact on the region from the ASRM termination. The SRB improvement activities also provide for modifications to booster hardware and ground support equipment.

The super lightweight tank funds the development of a lighter external tank using an aluminum lithium material that has been proven mature. The incorporation of the aluminum lithium alloy in the external tank would provide the Shuttle program with an opportunity to decrease Shuttle vehicle launch weight by 8000 pounds. This reduction can be used to place payloads in higher orbits or into orbits at a higher inclination to the equator. The super lightweight tank will take about forty-four months to develop and thus will be available to support the first element launch of the Space Station. The proposed schedule includes the time required for the remaining development effort, the design effort, the test of a tank

dedicated for structural verification, the build of the first super lightweight flight tank, and all the component requalification necessary for assurance that the super lightweight tank has all the integrity of its predecessor.

The launch site equipment upgrades budget funds investments in ground facilities at the launch site at the KSC to replace obsolete systems, to improve process efficiency, and to support the planned flight rate.

The major operational Space Shuttle facilities at KSC include three Orbiter Processing Facilities (OPFs), two launch pads, the Vehicle Assembly Building (VAB), the Launch Control Center (LCC), and three Mobile Launch Platforms (MLPs). These facilities support the pre-launch and post-landing processing of the four orbiter fleet. Key enhancements funded in launch site equipment include: implementation of a digital operational intercom system (DOIS); replacement equipment for the Launch Control Center, and improved Checkout, Control, and Monitoring System (CCMS II); replacement storage tanks and vessels for the propellants, pressurants, and gasses; an improved hazardous gas detection system (HGDS II); fiber optic cabling; and installation of a new orbiter ground cooling system.

The hardware interface module (HIM) cards at KSC are now obsolete and have caused an increased failure rate and repair cost over the past several years. The HIM upgrade will replace all chassis and cards with state-of-the-art "off the shelf" hardware to improve system reliability and maintainability. Design reviews have been completed and procurement was initiated in FY 1993. Installation should be completed by FY 1998.

The cable plant upgrade at KSC has been initiated to replace the miles of cables which support a wide variety of Shuttle facilities. Many of these cables were installed in the 1960s and are beginning to suffer increasing failure rates. Replacement will reduce the potential for disruption to critical Shuttle operations as well as have a direct maintenance benefit. This activity will reduce the possibility of launch delays, increase communication system spares availability, and enhance the reliability of data, instrumentation, voice, and video communications. This upgrade will replace the wideband distribution system and the lead/antimony sheath cables with fiber optics and plastic sheath, gel-filled cable. In addition, many field terminations will be replaced or upgraded as well as the manhole system. Other obsolete cable systems will also be replaced with current technology.

The flight operations upgrades budget funds JSC projects to improve capabilities or replace obsolete equipment such as: the Control Center Complex (CCC) equipment upgrade; the flight and ground support training facility improvements; and the flight design systems enhancements. Necessary improvements are being made for simulation training in both the Integrated Training Facility (ITF) and the CCC. The ITF upgrades include new host computers, interface hardware and simulator subsystems. The CCC will have improved console operations and communication equipment as well as new data processing and distribution systems. Critical reliability required for the longer integrated simulations will be substantially improved with these replacements. Also, associated maintenance costs will be reduced.

Other activities funded include implementing required modifications and upgrades on the T-38 aircraft used for space flight readiness training, modifications needed for the replacement Shuttle Training Aircraft (STA), capability improvements for weather prediction, and enhancements on information handling to improve system monitoring, notably for anomaly tracking.

As directed in P. L. 103-124, NASA has taken action to terminate the Advanced Solid Rocket Motor (ASRM) program. Although a final determination has not yet been made as to the total funding required for termination costs, the total amount is currently estimated to be in excess of $200 million, requiring the application of additional funds in excess of the $100 million identified for termination costs in the FY 1994 NASA appropriation.

Construction of facilities (CofF) for Space Shuttle projects, which were previously included in a separate appropriation, are now part of the safety and performance upgrades budget. The FY 1994 and FY 1995 funding is provided to refurbish, modify, replace and restore facilities at each of the OSF centers to improve performance and to insure their readiness to launch the Space Shuttle. For example, at KSC the cooling and electrical systems of launch complex-39 (LC-39) will refurbished. At JSC, the mission control center's air handling system must be replaced as must the thermal vacuum helium refrigeration system. Funding for facilities will henceforth be prioritized along with other program funding priorities.

BASIS OF FY 1995 ESTIMATE

Safety and Performance Upgrades encompasses Shuttle system improvements which will ensure safe and reliable performance and to expand existing safety margins. Included in the FY 1995 estimate are the Multifunctional Electronic Display System (MEDS), EDO, fiber optics to replace heavier copper cabling in the orbiter's payload bay, and other modifications to the orbiter. The FY 1995 estimate also funds SSME upgrades, improvements to the SRB and RSRM, and the development of a super lightweight external tank. Finally, this budget line supports launch site upgrades and flight operations upgrades in FY 1995, as well as construction of facilities required for the successful operation of the Shuttle program.

In FY 1995, the MEDS prime contractor and its subcontractors will continue to build prototype units in preparation for systems integration testing to be completed in FY 1996. Following this testing, the system will be ready for its first use. The MEDS installation and checkout in the orbiter fleet will occur during the normal in-line flow process at the KSC.

The orbiter improvements estimate supports the continuing development and implementation of improvements to the orbiter fleet for the enhancement of safety and performance, as well as economy of operations. Tasks to be continued in FY 1995 include continuing analysis of the external tank debris experienced during separation, upgrades to the rate gyro assembly which are also used in the SRB, and various orbiter support tasks such as Orbiter Maneuvering System/Reaction Control System (OMS/RCS) testing at White Sands. New

Mexico, modifications to the Remote Manipulator System (RMS), and support to the crew escape system. Replacement of the copper cabling in the payload bay with fiber optics will save approximately 1200 pounds per orbiter.

Development of a new long-life fuel cell will continue in FY 1995. Not only is a longer life fuel cell a key factor to ensure extended on-orbit operations, but also it lessens the frequency of changeouts and lowers overall maintenance, particularly if an external airlock is ultimately used.

The SSME upgrades are necessary improvements to expand existing safety margins and reduce operational costs. The FY 1995 projects include the alternate turbopump program (ATP), the large throat main combustion chamber (LTMCC), the SSME health monitoring system, and engine production testing and certification at the MSFC and the SSC.

The ATP funding in FY 1995 supports development and certification testing of the high pressure liquid oxygen (LOX) pump, with certification expected to be completed by mid-1995. Its first flight also will occur in FY 1995. The ATP implementation funding permits procurement of LOX pumps to outfit the engine fleet. The ATP fuel pump development funding is also included. Assuming Congressional approval in FY 1994, first flight is scheduled for 1998.

Since the first of four LTMCCs will be fabricated and used for hot-fire development testing in FY 1994, the FY 1995 funding will support the production of the other three units which are expected to be delivered in FY 1995.

The FY 1995 marks the start of upgrades to the SSME Health Monitoring System. Delivery of seven flight units is expected between July 1996 and August 1997. The preliminary design review schedule remains to be determined. Major milestones including the critical design review, testing, etc. will be achieved prior to committing to a production schedule.

The SSME production funding in the FY 1995 budget supports the continued development, testing, material procurement, fabrication, and engine assembly operations necessary to support the flight and ground test programs. The SSME ground test program is based on an average test rate of eight tests per month (460 seconds duration) through FY 1995. Fiscal Year 1995 marks the end of fabricating replacement flight engines lost through attrition. The remaining production effort will concentrate on producing improved components and spare engine hardware elements. The primary purpose of this testing is to develop and flight-certify improved components like the Phase II+ powerhead (two-duct hot-gas manifold), the single-coil heat exchanger, and the Alternate Turbopump. Ground testing will also be performed on all new or recycled flight hardware prior to government acceptance. Other testing will be performed to provide hot-fire experience and increase life limits of flight-configured engines. With the completion of certification testing on the single-coil heat exchanger and the Phase II+ powerhead, as well as the stabilization of the engine design,

the SSME program is scheduled to close out one of the three test stands (test stand B-1) now in use at the SSC after FY 1995. The two remaining stands will be used for acceptance tests of new and recycled hardware, for flight certification of upgrades such as the Large Throat Main Combustion Chamber (LTMCC), and for tests to extend hardware life limits.

The FY 1995 funding for SRB improvements supports continued efforts to improve the safety and producibility of the SRB, including the RSRM. Due to the termination of the ASRM, an asbestos-free RSRM will be implemented in 1997. The FY 1995 RSRM funding will provide for motor ground tests and for disposal of filament wound cases which had been produced and filled with propellant in the mid-1980's before the termination of the lightweight composite case effort. In addition, the budget supports RSRM and SRB project support activities at the MSFC.

With the termination of the ASRM program, alternate uses for the Yellow Creek site are being explored. The FY 1995 estimate assumes that the RSRM nozzle fabrication work will be moved from Utah to Iuka, Mississippi. As previously stated, NASA will provide Congress with the results of the ongoing ninety-day study for use of the facility prior to proceeding in FY 1994.

Development of a super lightweight external tank, made of an aluminum lithium alloy, will begin in FY 1994. In FY 1995, development will continue as design reviews are scheduled to be completed and fabrication is planned to begin in FY 1995. Delivery of the first flight unit is scheduled in time to support the Space Station first element launch schedule.

Funded in the Launch Site upgrades, HIM card hardware production units will be delivered to KSC and installation will be initiated and continued through FY 1995.

At KSC, the launch site equipment program funds the required upgrade of the Control, Checkout, and Monitoring System (CCMS II) in FY 1995. The CCMS II is part of the launch processing system that performs the real-time checkout, control, and monitoring for Shuttle processing. The current system is over twenty years old and has gone without any major technology upgrades for almost fifteen years. The CCMS II is currently in the installation phase in the processing control centers. The development should be complete by 1996 and full implementation is planned in 1998. In addition, other necessary upgrades and equipment replacements will be continued such as the orbiter ground cooling system, improved hazardous gas detection system, and improvements to the launch computer complex.

The flight operations upgrade funding in FY 1995 supports major equipment upgrades in the Control Center Complex (CCC) at the JSC. Fiscal Year 1995 will bring the replacement of aging equipment, such as the data processing and distribution system. Major system upgrades in the Integrated Training Facility (ITF) will continue with the acquisition of host and base interference computer replacements for the fixed and motion-based simulators. Associated software rehosting efforts and planning towards replacement of the instructor

operator stations will take place as well. The FY 1995 costs include replacing one Shuttle Training Aircraft (STA) and continuation of STA modifications. Funding supports the continuation of avionics upgrades to the fleet of T-38 aircraft as well as landing aids at the contingency/abort landing sites. In addition, the T-38s are undergoing structural and safety upgrades to prolong the aircraft service life through the auspices of the Air Force T-38 Pacer Classic program.

In FY 1995 under Construction of Facilities, replacement of the fire extinguisher system on launch complex-39 is planned, as is replacement of the launch processing component refurbishment facility (see Mission Support - Construction of Facilities budget for detailed information).

HUMAN SPACE FLIGHT

FISCAL YEAR 1995 ESTIMATES

OFFICE OF SPACE FLIGHT

PAYLOAD UTILIZATION AND OPERATIONS

	FY 1993	FY 1994	FY 1995	Page Number
		(Thousands of dollars)		
Spacelab	112,800	125,500	92,300	HSF 4-3
Tethered satellite system	4,000	7,400	9,700	HSF 4-6
Payload operations	95,200	92,100	62,600	HSF 4-8
Advanced projects	16,100	7,200	15,200	HSF 4-9
Engineering and technical base	214,200	180,400	176,400	HSF 4-12
Total	442,300	412,600	356,200	

Distribution of Program Amount by Installation

	FY 1993	FY 1994	FY 1995
Johnson Space Center	131,800	121,900	103,800
Kennedy Space Center	150,000	120,800	98,700
Marshall Space Flight Center	124,100	131,800	136,000
Stennis Space Center	6,500	2,400	1,800
Langley Research Center	300	300	--
Lewis Research Center	200	100	--
Goddard Space Flight Center	14,400	8,900	9,800
Jet Propulsion Laboratory	--	100	--
Headquarters	15,000	26,300	6,100
Total	442,300	412,600	356,200

OBJECTIVES AND JUSTIFICATION

The principal areas of activity in Payload Utilization and Operations include the operation of the Spacelab systems with some continuing development activities; a cooperative reflight of the U.S./Italian tethered satellite system (TSS); Payload Operations for accommodating NASA payloads; advanced projects; and the preservation of an Engineering and Technical Base capability at the manned space flight centers.

Spacelab and the Spacelab carrier systems were developed jointly by NASA and the European Space Agency (ESA). The Spacelab, a major element of the Space Transportation System (STS), provides a versatile, reusable laboratory which is flown to and from Earth orbit in the orbiter payload bay. The Spacelab carrier systems include pallets which provide payload mounting and support services (pointing, computer control system, data processing, power, cooling, etc.) for attached payloads outside the pressurized environments of the orbiter and Spacelab module. The Spacelab and carrier systems' development continues with a recertification program to insure flight safety, hardware procurement to support the flight program, and necessary upgrading of obsolete hardware to current technology.

The TSS, a joint U.S./Italian development effort, was flown in August 1992. The objectives of the initial TSS mission were twofold: (1) to verify the controlled deployment, operation, and retrieval of the TSS, and (2) to study the space plasma effects of electrical power generated by the conductive tether as it intersected the Earth's magnetic field. A mechanical interference prevented deployment to the twenty kilometer distance desired and, therefore, the major high voltage science was not obtained. NASA has completed a study with the Italian Space Agency on the technical and programmatic feasibility of reflying the TSS and, consistent with commitments to the Italian Space Agency, NASA will refly the TSS-1 mission. The current manifest opportunity is early 1996.

The payload operations program develops and places into operational status the ground and flight systems necessary to support NASA Shuttle payloads during prelaunch processing, on-orbit mission operations and, when appropriate, post-landing processing. Included within this program are the unique requirements for individual NASA payloads which use the Shuttle, multimission payload support equipment, and integration activities for the Shuttle.

Advanced projects conducts concept feasibility studies, selected systems definitions and preliminary design (Phase B) studies, and undertakes related high leverage advanced development activities providing the technical and programmatic data to identify evolving space transportation and systems requirements and to evaluate new technical capabilities. Activity is focused on two major areas: advanced operations support and advanced space systems. Planning in these areas includes activities to assess performance, reliability and operational efficiency improvements, and to reduce future program risks and development costs through the effective use of new technology.

The engineering and technical base preserves a fundamental scientific and technical core level capability for engineering services; independent safety, reliability, maintainability, and quality assurance (SRM&QA) oversight activity; mathematical and computer sciences activity; and various laboratories and facilities required by a wide variety of NASA programs at the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), and the Stennis Space Center (SSC).

BASIS OF FY 1994 FUNDING REQUIREMENT

SPACELAB

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Spacelab.......................................	112,800	125,500	92,300

OBJECTIVES AND STATUS

The Spacelab is a versatile, reusable facility designed for installation in the cargo bay of the Orbiter. Spacelab can serve as both an observatory and a laboratory, giving scientists the opportunity to conduct a large variety of scientific experiments in the unique environment of space. Ten foreign nations, including nine members of the European Space Agency (ESA), have participated in this joint development program with NASA. The ESA designed, developed, produced, and delivered the first Spacelab hardware consisting of a pressurized module and unpressurized pallet segments; an igloo which is used with pallets to supply services essential to the experiments; an instrument pointing subsystem (IPS); and much of the ground support equipment and software for both flight and ground operations.

There are two basic Spacelab configurations: modules and pallets. This hardware can be set up in a number of different configurations depending on the particular application, including using both a module and a pallet on the same mission. The modules consist of one or two cylindrical shells enclosed by two end cones. Users may choose either a short module (one cylinder) or a long module (two cylinders) to meet their particular needs. There are no current plans for a short module. Each module contains a core segment housing basic subsystems (power, cooling, computers, data handling, etc.) and an experiment segment carrying racks for conducting various experiments. The module is pressurized to allow a "shirt sleeve" working environment. Easy crew access from the Shuttle middeck during flight is provided by a pressurized tunnel. Modules are generally used for life sciences and space processing applications such as the United States Microgravity Laboratory (USML) and Space Life Sciences (SLS) series of missions.

Spacelab pallets are unpressurized and consist of multiple segments attached individually to the Orbiter, or up to three segments attached rigidly to each other and to the Orbiter in a continuous train. If pallets are flown without a module, essential subsystems can be carried in an "igloo" which provides a pressurized and thermally-controlled environment for the subsystem equipment. The igloo is not accessible to the crew inside the Orbiter. Experiments mounted on a pallet can be controlled from the Orbiter cabin, from the ground, or from a module, if the payload complement contains a module. NASA has developed two principal versions of the Spacelab Pallet System (SPS). One supports missions requiring the use of the Spacelab

computer system and pallet in a mixed cargo configuration like the Atmospheric Laboratory for Applications and Science (ATLAS) missions. The other version, the Enhanced Multiplexer/demultiplexer Pallet (EMP), supports missions such as the tethered satellite system (TSS) and the Space Radar Laboratory (SRL) which do not require the use of the Spacelab computer system.

Spacelab development funding includes additional hardware to maintain the Spacelab carrier system, ground support equipment, hardware modifications, hardware acquisition, system recertification, and modified or improved hardware to expand Spacelab capabilities and ensure its continued operational availability. Support software and procedures development, testing, and training activities are also included in NASA's funding request. Additional Spacelab hardware, including spare hardware, is being procured from European and U.S. sources as needed to support the flight manifest.

Spacelab operations support includes mission planning, mission integration, and flight and ground operations. This includes integration of the flight hardware and software, mission independent crew training, system operations support, payload operations control support, payload processing, logistical support and sustaining engineering. The Spacelab operations cycle is repeated with each Spacelab flight but with a different payload complement. This cycle consists of three integration steps. Level IV provides for the integration and checkout of experiment equipment with individual experiment mounting elements like racks and pallet segments, and is funded by the payload sponsor. This activity is normally performed at the Kennedy Space Center (KSC), but is not part of the Spacelab Operations budget. Level II/III integration then combines and integrates all experiment mounting elements like racks, rack sets, and pallet segments, which have the experiment equipment already installed, and for check out with the Spacelab software. This activity is done at KSC and is funded under the Spacelab budget. Level I integration takes the Spacelab and its payload, for integration and checkout with the Shuttle orbiter. Level I integration is performed by both the Spacelab contractor and the Shuttle Processing Contractor (SPC). The Spacelab budget funds that portion of Level I integration performed by the Spacelab contractor. The balance is funded in the Shuttle Operations budget.

Spacelab Operations also funds smaller tertiary and secondary payloads like the Get-Away Specials (GAS) and Hitchhiker payloads. The GAS payloads are research experiments which are flown in standard canisters and can fit either on the sidewall of the cargo bay or across the bay on a GAS bridge. They are the simplest of the small payloads with limited electrical and mechanical interfaces. To date, ninety-seven GAS payloads have been flown and thirty-three are in preparation. The Hitchhiker payloads are the more complex of the smaller payloads; they provide opportunities for larger, more sophisticated experiments. The Hitchhiker system employs two carrier configurations: (1) an orbiter payload bay side wall configuration and (2) a cross payload bay configuration that uses a Multi-Purpose Experiment Support Structure (MPESS). During the mission, the Hitchhiker payloads can be controlled using the aft flight deck computer/standard switch panels or on the ground through the Payload Operations Control Center. Four Hitchhikers were flown in FY 1993 and additional flights are planned in FY 1994-FY 1995, such as the International Extreme Ultraviolet (IEU-1) and

Capillary Pump Loop/Orbital Debris Radar Calibration Spheres Project (CAPL/ODERACS). In addition, Hithchiker-Junior (HH-JR) hardware is being developed in FY 1994 to fly payloads that are more complex than GAS but less complex than Hitchhiker. The HH-JR will provide an intermediate range of services such as pointing and crew operations.

Another item funded in Spacelab operations is the Flight Support System (FSS). The FSS consists of three standard cradles with berthing and pointing systems along with avionics. It is used for on-orbit maintenance, repair, and retrieval of spacecraft. The FSS was used on the Hubble Space Telescope (HST) repair/revisit mission.

In FY 1993 one Spacelab module mission was successfully completed -- the partially reimbursable German Spacelab mission (SL-D2). Six additional missions utilized Spacelab and Shuttle carriers, including the Atmospheric Laboratory for Applications and Science (ATLAS-2), the United States Microgravity Payload (USMP-1) and four Hitchhiker missions. In FY 1994 two Spacelab module missions are planned -- the Space Life Science Laboratory-2 (SLS-2) and the International Microgravity Laboratory-2 (IML-2). In addition, four other missions utilizing Spacelab carriers will fly: USMP-2, SRL-1, SRL-2, and Lidar In-space Technology Experiment-1 (LITE 1). Along with these major missions are numerous smaller Spacelab carriers such as Hitchhikers and Get-Away Specials.

In addition to the support of these missions, analytical and physical integration, configuration management, and software development for future flights will be conducted. Procurement of spares for both NASA-developed hardware and for hardware developed by U.S. companies under contract with ESA will continue throughout FY 1994 as will operation of the depot maintenance program.

BASIS OF FY 1995 ESTIMATE

The FY 1995 Spacelab program funding reflects the program requirements to conduct Spacelab missions consistent with the manifest. Missions to be flown in FY 1995 include ATLAS-3, ASTRO-2, and USML-2. In addition, a Spacelab Life Science mission will dock with the Russian Space Station Mir (SL-M) and Spacelab will support two Hitchhiker payloads and two GAS bridges. Efforts will continue to process payloads for the Russian follow-on missions to Mir beginning in late 1995. Efforts are underway to decrease Spacelab operational costs by realigning, where appropriate, work previously performed by mission support contractors to performance by civil servants, by reducing documentation requirements and reviewing logistical support. All Spacelab requirements and services in support of the cooperative missions to the Russian Mir Space Station are budgeted within the Russian Cooperation program.

BASIS OF FY 1995 FUNDING REQUIREMENT

TETHERED SATELLITE SYSTEM

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Tethered satellite system-1	4,000	--	--
Tethered satellite system reflight	--	7,400	9,700
Total	4,000	7,400	9,700

OBJECTIVES AND STATUS

The tethered satellite system (TSS) was developed as a cooperative program with Italy to provide a reusable space facility for conducting space experiments at distances up to 100 kilometers from the Shuttle orbiter while being held in a fixed position relative to the Orbiter. During the demonstration mission flown in August 1992, the TSS verified its capability to provide a dynamically stable research facility, but a mechanical interference prevented completion of the science mission. In response to an Italian Space Agency request to refly the mission, NASA conducted a reflight study, including an independent assessment of NASA's future use of tethered satellites. The study concluded that a reflight mission could be readily accomplished and recommended several improvements to enhance the probability of success. The independent assessment identified a number of significant and unique science and engineering objectives which could be accomplished using tethered satellites, and urged the continued development and utilization of the tethered technology. NASA, in response to the request from the Italian Space Agency, has agreed to refly the TSS-1 mission. The current manifest opportunity is early 1996.

The U.S. is responsible for overall program management, overall systems engineering and integration, orbiter integration, ground and flight operations, development of the deployment mechanism and provision of the non-European instruments (Office of Space Science funded). The Italians are responsible for the design and development of the satellite and the European instruments being flown on the joint mission.

BASIS OF FY 1995 ESTIMATE

The FY 1995 tethered satellite system reflight funding will be used for the TSS Shuttle integration effort, developing a plan for the mission, and training for the mission operations. The funding level is based on using Marshall Space Flight Center civil servant personnel to a far greater extent than was the case for the first mission. About $2.5 million of the FY 1995 budget will be used to purchase the ground support equipment capitalized by the prime contractor.

BASIS OF FY 1995 FUNDING REQUIREMENT

PAYLOAD OPERATIONS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Payload operations	95,200	92,100	62,600

OBJECTIVES AND STATUS

The Payload Operations program provides payload services which are required beyond the standard Shuttle Services for NASA missions and reusable support equipment for all payload operations. These optional services include: (1) retrieval services, analysis for rendezvous, and proximity operations; (2) special thermal analysis; (3) any modifications to ground facilities particularly in the Shuttle Mission Simulator (SMS) above the standard service; (4) extra shifts required in the Shuttle Engineering Simulator (SES) or any other facilities to satisfy the customer requirements; (5) payload-related Extravehicular Activity (EVA) above the standard service; (6) special training or use associated with operation of the Remote Manipulator System (RMS); (7) special services between the Payload Operations Control Center (POCC) and the Mission Control Center (MCC); and (8) any special analysis, testing, or other service not normally included in the standard Shuttle service.

Payload support equipment is included in this program supporting the development, testing, and delivery of payload accommodation equipment and capabilities common to multiple NASA missions. A major category is the communications equipment necessary for payload data transmission during ground processing and checkout. This equipment includes fiber optic cabling and an upgraded operations intercom system in the industrial area at the Kennedy Space Center (KSC) to provide increased flexibility and quality of data transmission among the various payload facilities. Payload operations, maintenance and logistics support are provided to cargo support equipment, such as cargo integration test equipment and multimission support equipment, and to the payload support areas, such as the Vertical Processisng Facility, the Operations and Checkout Building and cargo hazardous servicing facilities.

BASIS OF FY 1995 ESTIMATE

The FY 1995 Payload Operations funding supports payload services and mission unique integration for scheduled NASA missions. Funding for multimission payload support equipment provides a contractor workforce to process payloads and provide payload integration and testing support. In addition, funding supports continued upgrades to the fiber optic cable plant. Payload launch support provides launch site managers to payload customers and allows verification of the cargo-to-orbiter interface for current missions. Major

NASA missions with FY 1995 funding requirements include the FY 1995 flights of ASTRO-2, the United States Microgravity Laboratory (USML-2), the ATLAS-3; FY 1996 flights include the Tethered Satellite System reflight, United States Microgravity Payload-3 (USMP-3), and the Orbiting Retrievable Far and Extreme Ultraviolet Spectrometer - Shuttle Pallet Satellite-2 (ORFEUS-SPAS-2). Funding also provides for services to future manifested missions, including the Microgravity Science Laboratory (MSL-1) and USMP-4 missions. All payload operations requirements and services in support of the cooperative missions to the Russian Mir Space Station are budgeted within the Russian Cooperation program.

BASIS OF FY 1995 FUNDING REQUIREMENT

ADVANCED PROJECTS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Advanced projects..............................	16,100	7,200	15,200

OBJECTIVES AND STATUS

The advanced projects budget includes the development of advanced technologies benefiting both space operations and space systems. The advanced operations program continues pursuit of its goal of reducing the cost of ground and mission operations of the Space Shuttle and Space Station through the introduction of advanced technologies into the operations environment. Achieving the budget reductions reflected in the Space Shuttle Operations and the Space Station Operations budgets is dependent on successful implementation of the advanced operations projects. Estimated cost savings through the introduction of advanced operations projects into human mission operations are realized through reduced manpower for mission operations computer support, orbiter process scheduling, and software verification. Other advanced operations projects will significantly reduce the cost of processing the orbiter, training astronauts for the various missions, and scheduling mission simulations.

The advanced space systems program includes the orbital debris program and a series of flight experiments in the following areas: system enabling flight demonstrations, orbital debris, and tether applications. Flight demonstrations also provides training for young NASA engineers and managers with early "hands-on" flight hardware experience. Since FY 1993, a total of five successful flight demonstrations were conducted. The Fluid Acquisition and Resupply Flight Demonstration (FARE-1), the Fluid Acquisition and Resupply Flight Demonstration (FARE-2), and the Superfluid Helium On-Orbit Transfer (SHOOT) flight demonstration were flown on the Space Shuttle. The FARE flight demonstrations were utilized to obtain essential low-gravity fluid transfer data that are applicable to Space Station to increase the efficiency of fluid transfer operations and by the Space Shuttle to increase the safety and efficiency of extended duration flights. This data will also be useful in increasing the effectiveness of fluid transfers by unmanned space systems thus decreasing the cost of these programs. The SHOOT flight demonstration not only demonstrated the feasibility of superfluid helium transfers on orbit at operational rates, but it also set the precedent for cryogenic payload safety on both Space Shuttle and Space Station. The hardware, software and operational procedures developed as part of the SHOOT flight demonstration will result in future cost savings to other microgravity payloads. The SHOOT cryogenic hardware components have already become industry standards.

The Small Expendable Deployer (SEDS-1) flight demonstration, and the Plasma Motor/Generator (PMG) flight demonstration were tether applications experiments that were flown as secondary payloads aboard Delta II launch vehicles. The SEDS flight demonstration proved the technology readiness of these low cost and safe systems which have promising applications for the routine deorbiting of Space Station materials and emergency medical samples as well as the placement of instruments into the upper atmosphere. SEDS-1 also demonstrated the feasibility of using these low cost tether applications test beds for improving the efficiency of in-space operations. The PMG flight demonstration proved the ability of the proposed Space Station plasma grounding techniques for maintaining the electrostatic potential between the Space Station and the surrounding plasma medium. The PMG also demonstrated the ability to use electrostatic tethers to provide thrust to offset drag in low-Earth orbit (LEO) space systems. PMG also demonstrated the use of direct magnetic (non-rocket) propulsion for orbital maneuvering.

The orbital debris program is directed at measuring the orbital debris environment, developing debris growth mitigation measures, and enhancing spacecraft protection and survivability. A total of 2000 hours of debris environment observations reduced the uncertainty in that environment from 300% to approximately 50%. In addition, the first survey of the orbital debris environment at geostationary altitudes was initiated. The orbital debris environment data provided to Space Station enabled the development of cost effective shields to increase the design efficiency of the Space Station in protecting against the orbital debris environment. These continuing environmental measurements are the basis for studying and understanding future orbital debris mitigation measures which will result in lowering the cost of, as well as improving the safety of, Space Station and Space Shuttle operations. This data also provided the necessary inputs to the Space Shuttle for the development of flight rules which not only increase the safety on long-duration Shuttle missions but also result in minimum damage due to orbital debris, thereby decreasing the Space Shuttle refurbishment costs resulting from orbital debris damage. Geostationary orbital debris data is being utilized to develop cost effective debris mitigation techniques to protect vital geostationary assets.

BASIS OF FY 1995 ESTIMATE

Advanced operations efforts will continue to identify and demonstrate technologies which will improve efficiency, flexibility, and reliability of current and future human space flight systems. The selective application of expert systems, automation, and other technologies to labor intensive and hazardous operations are included in advanced operations studies. Launch processing systems, mission control applications, flight planning, training, simulation and other environments will be targeted to demonstrate emerging technologies for improving ground and flight operations cost efficiencies. The FY 1995 budget request will permit level-of-effort funding for several cost effective technologies including the ground processing scheduling system and several computer software systems tools to more efficiently conduct Shuttle ground and launch operations.

Advanced space systems emphasis will be placed on the demonstration of transportation and Space Station-related flight systems. During FY 1995, work will proceed on the Students for the Exploration and Development of Space Satellite (SEDSAT) tether applications flight demonstration as well as elements of the six projects selected as part of the fourth call for flight demonstrations. There are the Low Poer Ion Propulsion Technology Validation, the Metals Processing in Space Using the Ukrainian Universal Hand Tool, the collection or orbital debris on Mir, the Dexterous Orbiter Servicing System, the Static Feed Water Electrolysis Flight Demonstrations, and a ground-based Automated Rendezvous and Docking experiment. Orbital debris activities will be focused on characterizing chanages in the orbital debris environment as a function of time and establishing measures for mitigation of debris growth trends and spacecraft protection techniques.

BASIS OF FY 1995 FUNDING REQUIREMENT

ENGINEERING AND TECHNICAL BASE

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Engineering and technical base..................	214,200	180,400	176,400

OBJECTIVES AND STATUS

The objective of the engineering and technical base (ETB) program is to preserve a fundamental scientific and technical core level capability for the Office of Space Flight (OSF) centers: Johnson Space Center (JSC) including White Sands Test Facility (WSTF), Kennedy Space Center (KSC), Marshall Space Flight Center (MSFC), and Stennis Space Center (SSC). This capability preserves scientific and technical knowledge and testing technology in the science and engineering laboratories including technical and testing facilities. The ETB consists of five interrelated functions: science and engineering laboratories and technical facilities; engineering computation facility Class VI supercomputers; independent safety, reliability, maintainability and quality assurance (SRM&QA) activity; engineering laboratory services such as instrumentation and calibration, fabrication, documentation/image processing/visual information, non-destructive evaluations to complement the S&E tasks; and the automatic data processing (ADP) operations and equipment activity to accomplish essential mathematical and computer sciences tasks for S&E operations.

The ETB program provides personnel and materials for research and test operations in crew and thermal activity, tracking and communications, navigation and control, flight data systems, propulsion and power systems, automation and robotics, structures and mechanics, systems engineering, space and life sciences, SRM&QA oversight functions, operation of the technology test bed (TTB) at MSFC, and engineering computational facility Class VI supercomputer operations. At JSC, ETB funding provides for the JSC ADP operations, equipment and supplies associated with the Center's systems and network, the central computing facility, and the Integrated Software Technology Laboratory (ISTL). The ETB also provides the KSC launch site with operations critical to scientific, engineering and technical labs and facilities. In addition to these development efforts, operations support also provides crucial engineering laboratory services such as instrumentation calibration, non-destructive evaluation, and chemical sampling and analysis. The ETB program funding preserves and provides ongoing maintenance critical to specialized technical facilities and equipment in the laboratories and facilities at the Centers.

BASIS OF FY 1995 ESTIMATE

The FY 1995 engineering and technical base funding will preserve minimal support to crew and thermal activity; tracking and communications activity; navigation and control; flight data systems; propulsion and power activity; automation and robotics, structures and mechanics; systems engineering; basic maintenance and operations of propulsion test stands and laboratory operations; and maintain minimal scientific, engineering and technical operations at the launch site. Reductions in FY 1995 have been taken in the science and engineering laboratories and technical facilities, Class VI supercomputing capability, independent safety, reliability, and quality assurance, and engineering laboratory services. In addition, there has been an increase in educational research grants which will provide for OSF requirements supporting Agencywide goals.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1995 ESTIMATES

GENERAL STATEMENT

The Science, Aeronautics and Technology appropriation provides funding for the research and development activities of NASA. This includes funds to extend our knowledge of the Earth, its space environment, and the universe; and to invest in new technologies, particularly in aeronautics, to ensure the future competitiveness of the nation. These objectives are achieved through the following elements:

Space Science: This program conducts a broad spectrum of scientific investigations to advance our knowledge of the sun, the planets, interplanetary and interstellar space, and the stars of our galaxy and the universe.

Life and Microgravity Sciences and Applications: A program to identify and develop the technology for the useful applications of space techniques in the area of materials process research and experimentation, and to explore the effect of the zero-gravity environment of space on human physiology.

Mission to Planet Earth: A program to provide for the use of space systems, supported by ground-based and airborne observations, to acquire information which will assist in the solution of Earth resources and environmental problems.

Aeronautical Research and Technology - A program to conduct the fundamental long-term research to strengthen the United States leadership in aviation, and to pursue development of high leverage technologies required to support both the subsonic and high-speed civil transport economic viability.

Advanced Concepts and Technology - A program to support the development and application of technologies critical to the economic, scientific, and technological competitiveness of the United States.

Launch Services - A program to provide for procurement of expendable launch vehicle services.

Mission Communication Services - Funding for communications activities which are most directly related to NASA's science and aeronautics programs.

Academic Programs - A program to support Agencywide university, minority university, and elementary and secondary school programs.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1995 BUDGET ESTIMATES

(IN MILLIONS OF REAL YEAR DOLLARS)

	BUDGET PLAN		
	1993	1994	1995
SCIENCE, AERONAUTICS AND TECHNOLOGY	4,908.7	5,847.3	5,901.2
SPACE SCIENCE	1,510.4	1,721.9	1,766.0
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS	407.5	515.3	470.9
MISSION TO PLANET EARTH	936.3	1,024.5	1,238.1
AERONAUTICAL RESEARCH AND TECHNOLOGY	769.4	1,102.2	898.5
ADVANCED CONCEPTS AND TECHNOLOGY	464.9	495.3	608.4
LAUNCH SERVICES	180.8	313.5	340.9
MISSION COMMUNICATION SERVICES	546.5	589.1	481.2
ACADEMIC PROGRAMS	92.9	85.5	97.2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

Science, Aeronautics and Technology

For necessary expenses, not otherwise provided for, for the conduct and support of science, aeronautics, and technology research and development activities, including research; development; operations; services; maintenance, construction, repair, rehabilitation and modification of real and personal property; acquisition or condemnation of real property, as authorized by law; space flight, spacecraft control and communications activities including operations, production, and services; and purchase, lease, charter, maintenance, and operation of mission and administrative aircraft; $5,901,200,000, to remain available until September 30, 1996.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SCIENCE, AERONAUTICS AND TECHNOLOGY

REIMBURSABLE SUMMARY

(IN MILLIONS OF REAL YEAR DOLLARS)

	BUDGET PLAN		
	1993	1994	1995
SCIENCE, AERONAUTICS AND TECHNOLOGY	512.2	700.5	562.5
SPACE SCIENCE	5.2	122.0	114.5
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS	0.5	1.3	1.2
MISSION TO PLANET EARTH	319.6	260.0	234.0
AERONAUTICAL RESEARCH AND TECHNOLOGY	101.3	107.0	112.0
ADVANCED CONCEPTS AND TECHNOLOGY	37.3	117.0	52.0
LAUNCH SERVICES	47.5	92.0	48.0
ACADEMIC PROGRAMS	0.8	1.2	0.8

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

FISCAL YEAR 1995 ESTIMATES
DISTRIBUTION OF SCIENCE, AERONAUTICS AND TECHNOLOGY BUUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Goddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA HQ
Space Science	1993	1,510,459	13,700	0	218,250	0	681,483	351,624	44,947	713	154	199,588
	1994	1,721,900	3,690	0	297,776	0	644,958	525,352	37,852	0	0	212,272
	1995	1,766,000	3,360	0	322,144	0	641,093	582,541	31,259	0	0	185,603
Life and Microgravity Sciences and Apps	1993	407,500	89,600	19,400	93,200	0	300	33,700	49,600	3,600	67,300	50,800
	1994	515,300	119,800	22,400	113,400	0	500	20,600	67,600	3,300	76,600	91,100
	1995	470,900	115,000	19,000	110,700	0	200	8,500	83,000	2,700	69,800	62,000
Mission to Planet Earth	1993	936,316	211	75	10,467	711	607,142	114,616	39,518	24,955	4,063	134,558
	1994	1,024,500	130	100	29,100	600	605,400	167,200	35,900	41,600	3,500	140,970
	1995	1,238,100	130	100	7,100	500	815,000	203,400	34,000	43,300	1,900	132,670
Aeronautical R & T	1993	769,362	0	0	0	0	6,421	3,753	293,425	230,688	199,932	35,143
	1994	1,102,200	400	0	500	0	19,300	4,800	304,300	381,900	262,400	128,600
	1995	898,500	0	0	0	0	17,600	6,000	260,700	337,200	251,700	25,300
Adv Concepts & Tech	1993	464,900	62,698	3,640	41,524	6,325	22,588	50,781	27,687	49,601	68,918	131,138
	1994	495,300	52,900	2,600	49,700	8,800	17,500	50,700	22,900	41,500	74,500	174,200
	1995	608,400	66,140	12,077	73,683	13,004	33,370	75,795	25,316	68,767	54,590	185,658
Launch Services	1993	180,801	0	12,700	46,957	0	71,934	200	0	0	46,178	2,832
	1994	313,500	0	12,000	43,600	0	92,400	0	0	0	148,000	17,500
	1995	340,900	0	12,400	31,400	0	114,200	0	0	0	156,400	26,500
Mission Comm Services	1993	546,488	0	0	0	0	276,612	221,035	18,463	0	0	30,378
	1994	589,100	0	0	0	0	324,816	220,006	14,300	0	930	29,048
	1995	481,200	0	0	0	0	260,800	179,300	18,300	0	1,500	21,300
Academic Programs	1993	92,900	1,603	1,680	2,522	1,655	2,653	2,815	1,505	2,756	2,259	73,452
	1994	85,500	2,829	1,876	2,880	1,709	3,220	3,308	1,719	3,276	2,595	62,088
	1995	97,200	3,636	2,152	3,685	1,833	4,115	4,149	1,843	4,245	3,185	68,357
TOTAL BUDGET PLAN	1993	4,908,726	167,812	37,495	412,920	8,691	1,669,133	778,524	475,145	312,313	388,804	657,889
	1994	5,847,300	179,749	38,976	536,956	11,109	1,708,094	991,966	484,571	471,576	568,525	855,778
	1995	5,901,200	188,266	45,729	548,712	15,337	1,886,378	1,059,685	454,418	456,212	539,075	707,389

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1995 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995	Page Number
Physics and Astronomy	1,034,861	1,067,600	1,058,700	SAT 1.1
Planetary Exploration	475,598	654,300	707,300	SAT 1.2
Total	1,510,459	1,721,900	1,766,000	

C-2.

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1995 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

PHYSICS & ASTRONOMY

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1993	FY 1994	FY 1995	Page Number
		(Thousands of dollars)		
Advanced x-ray astrophysics facility development	168,337	241,300	234,300	SAT 1.1-6
Relativity mission development	27,000	42,400	50,000	SAT 1.1-8
Global geospace science	72,647	13,300*	--*	SAT 1.1-10
Payload and instrument development	74,240	59,500	47,900	SAT 1.1-12
Explorer development	115,832	123,300	120,400	SAT 1.1-15
Mission operations and data analysis	415,402	420,700	441,700	SAT 1.1-18
Research and analysis	71,558	71,100	71,100	SAT 1.1-22
Suborbital program	64,843	69,500	67,200	SAT 1.1-24
Information systems	25,002	26,500	26,100	SAT 1.1-26
Total	1,034,861	1,067,600	1,058,700	
Distribution of Program Amount by Installation				
Johnson Space Center	--	13	13	
Marshall Space Flight Center	217,250	297,776	322,144	
Lewis Research Center	154	--	--	
Ames Research Center	34,315	32,108	28,251	
Goddard Space Flight Center	656,908	625,916	599,929	
Jet Propulsion Laboratory	40,224	38,073	38,091	
Headquarters	86,010	73,714	70,272	
Total	1,034,861	1,067,600	1,058,700	

* Funding requirements under review

OBJECTIVES AND JUSTIFICATION

The primary objectives of the Physics and Astronomy program are to increase our understanding of the origin and evolution of the universe, the fundamental laws of physics, and the formation of stars and planets. Research teams involved in this program are located at universities, industrial laboratories, NASA field centers, and other government laboratories. The scientific information obtained and the technologies developed are made available to the scientific communities and the general public for the advancement of scientific knowledge, education, and technology. Two science programs are supported by funds provided under Physics and Astronomy: astrophysics and space physics. In addition, Physics and Astronomy funding supports improved science data management, analysis, and visualization techniques to improve scientists' productivity through the Information Systems program.

Objects studied by the astrophysics program include distant galaxies and galactic clusters, as well as stars and other structures in nearby galaxies and the interstellar medium within our own galaxy. Unusual and exotic phenomena such as quasars, neutron stars, pulsars, and black holes are of particular interest to the astrophysics program, and are the target of many ground-based and space-based research programs. Astronomical observations from space avoid images from being obscured or distorted by the atmosphere. While many wavelengths are obscured by the atmosphere, some wavelengths actually cannot be observed from the surface of the Earth at all. The astrophysics program also supports a limited number of initiatives related to relativity science.

The attention of NASA's space physics program is upon naturally-occurring plasmas, the physical state of 99% of the universe. The study of relatively cool plasmas in the planetary ionospheres, the hot plasma of the sun, Earth and other planets' magnetospheres, and galactic cosmic-ray plasma are all emphasized. Study of Earth's nearby space environment has revealed a dynamic and complex system of plasmas interacting with the magnetic fields and electric currents surrounding our planet. This region, comprised of the magnetized solar-wind plasma plus the perturbation in the heliosphere caused by the presence of the magnetic Earth, is referred to as geospace.

The objectives of the astrophysics and space physics programs are accomplished using a mixture of small, medium, and large spacecraft, instruments and payloads to be flown on international and U.S.- developed satellites and Shuttle/Spacelab flights, and suborbital missions. The entire program rests on a solid basis of supporting research and technology, data analysis, and theory. Recently launched spacecraft have been

extremely successful, including the Cosmic Background Explorer (COBE, 1989), the Combined Release and Radiation Effects Satellite (CRRES, 1990), the Hubble Space Telescope (HST, 1990), the Compton Gamma Ray Observatory (CGRO, 1991), the Extreme Ultraviolet Explorer (EUVE, 1992), and the Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX, 1992). Recent Spacelab missions include Astro-1 (1990), the Diffuse X-ray Spectrometer (DXS, 1993), Spartan 201 (1993), and the Orbiting Retrievable Far and Extreme Ultraviolet Spectrometer (ORFEUS, 1993). NASA has also recently participated in international programs such as the German Roentgen Satellite (ROSAT, 1990), the Japanese Solar-A/Yohkoh (1991), the Geotail (1992) and the Astro-D (1993) missions.

The Advanced X-ray Astrophysics Facility (AXAF) was approved by Congress in FY 1989 contingent upon demonstration of mirror fabrication technologies. The AXAF met the Congressional milestones and has proceeded with science instrument development, continued fabrication and test of its grazing incidence mirrors, and design of spacecraft, telescope, and mirror assemblies. Following a restructuring of this system in 1992, AXAF was divided into two satellites (AXAF-I and AXAF-S) to be launched in 1998 and 1999. Together, the two satellites would provide high resolution imaging and both wide-band and narrow-band coverage of the x-ray spectrum necessary for both cataloging study and specific investigation of the composition and nature of galaxies, stellar objects, and interstellar phenomena, and the study of basic issues in theoretical physics. In the FY 1994 appropriation, Congress directed NASA to cease work on the AXAF-S spacecraft and to investigate the potential for flight of the X-Ray Spectrometer (XRS) instrument on Astro-E, a future Japanese mission. Consistent with this direction, the program has taken the necessary actions to terminate the AXAF-S mission. Studies are currently underway to examine the technical and scientific merits as well as the schedule and fiscal requirements for flying XRS aboard the Astro-E mission.

Two previously existing budget elements, Gravity Probe-B (GP-B) development and the Shuttle Test of Relativity Experiment (STORE), are now consolidated into a single budget element called Relativity Mission Development. STORE is a technology demonstration program designed to validate the technologies and performance requirements of the dewar and probe which will ultimately fly aboard the GP-B mission. This was previously funded under Payload and Instrument Development. The GP-B will incorporate instrument hardware developed by the STORE mission into a free-flying spacecraft designed to test key elements of Einstein's general theory of relativity. After a lengthy period of science definition, technology demonstration, and design and test of prototype components, GP-B development started in FY 1993 with a launch targeted for FY 2000 aboard a Delta II launch vehicle.

The Space Physics program is currently developing two satellites under the Global Geospace Science (GGS) program and several instruments and spacecraft subsystems under the Collaborative Solar Terrestrial Research (COSTR) program. The COSTR instruments and subsystems will be flown on several international satellites. These two NASA programs represent the U.S. contribution to the International Solar Terrestrial Physics (ISTP) program, a broad initiative to conduct advanced observations and study of the sun and Earth's

geospace. Under this program, satellites are being developed by NASA and the European Space Agency (ESA), plus one satellite already produced by the Japanese Institute of Space and Aeronautical Science (ISAS).

NASA's two GGS spacecraft, Wind and Polar, together with Japan's Geotail which was launched in 1992 and other Earth observing and near-Earth satellites, will make the first coordinated geospace measurements of the interaction between the Earth's magnetic field and plasma from the sun, and the transfer of mass, energy, and heat to the Earth system. The Wind spacecraft will study this transfer at the head of the geospace, the Polar at the Earth's poles, and the Geotail at a point where the Earth's magnetic region tails away toward the outer solar system.

Payload and Instrument Development supports a number of instruments and payloads to be used on international satellites or on Spacelab missions. These include the Collaborative Solar Terrestrial Research (COSTR) program, which will provide instruments and subsystems for the European Space Agency (ESA)-developed Solar and Heliospheric Observatory (SOHO) and Cluster missions, in addition to the support already provided for the Japanese Geotail spacecraft launched in 1992; the science requirements for a Tethered Satellite System (TSS) reflight; and a variety of other small astrophysics and space physics instruments.

Explorer missions are selected to conduct investigations of an exploratory or survey nature, or to achieve specific objectives which do not require the capabilities of a large spacecraft or observatory. The X-ray Timing Explorer (XTE), the Advanced Composition Explorer (ACE), the Submillimeter Wave Satellite (SWAS), and the Fast Auroral Snapshot (FAST) are all currently under development within the Explorer program. The SWAS and the FAST are classified as Small Explorers (SMEX).

The Mission Operations and Data Analysis (MO&DA) program supports satellite operations during the performance of the core missions of astrophysics and space physics spacecraft, and for ongoing analysis of selected data sets. Funding is also applied to pre-flight preparations for NASA satellite operations and data analysis activities, and for long-term data archiving and data base services. In addition, funds from this category are used to support ongoing servicing support for the Hubble Space Telescope (HST).

Suborbital observations from balloons, sounding rockets, and high-flying aircraft provide low-cost, frequent access to regions in the upper atmosphere which are not accessible from orbital spacecraft. The program continues to provide valuable opportunities to conduct science and to develop and test instruments which will ultimately fly aboard orbital spacecraft.

The Research and Analysis (R&A) program provides ongoing support for basic and applied research, new technology development and theory-building. Research teams at NASA centers and at universities, industrial laboratories, and other government laboratories are supported. The scientific discoveries and technological advances derived from this program are ultimately made available to the science community and the private sector for the advancement of scientific knowledge, education and industrial application.

The Information Systems program continues to provide a state-of-the-art environment to support science research objectives. This includes ongoing developments in high performance networking and computing capabilities, interactive analysis techniques with expedient access to multiple data sets, enhancement of mathematical processes tools, and advanced visualization techniques. These activities are all designed to enhance access to and exploitation of existing and future scientific data sets.

BASIS OF FY 1995 FUNDING REQUIREMENT

ADVANCED X-RAY ASTROPHYSICS FACILITY DEVELOPMENT

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Advanced x-ray astrophysics facility	168,337	241,300	234,300
Mission operations and data analysis	(14,900)	(11,600)	(18,900)
Upper stages	(--)	(7,800)	(16,600)

OBJECTIVES AND STATUS

The Advanced X-ray Astrophysics Facility (AXAF) will observe matter at the extremes of temperature, density, and energy content. Previous x-ray missions such as the Small Astronomical Satellite-C (SAS-C) and the High Energy Astronomical Observatory-2 (HEAO-2) have demonstrated that observations in the x-ray band provide a powerful probe into the physical conditions of a wide range of astrophysical systems. With its unprecedented capabilities in energy coverage, spatial resolution, spectral resolution, and sensitivity, AXAF will provide unique and crucial information on the nature of objects ranging from nearby stars to quasars at the edge of the observable universe. The AXAF is the third of NASA's Great Observatories, and has been given high priority by the National Academy of Sciences Astronomy Survey Committee.

The Marshall Space Flight Center (MSFC) was assigned responsibility for managing the AXAF project in 1978, subsequent to the successful High Energy Astrophysics Observatory (HEAO) program that was nearing completion. The scientific payload was selected through an Announcement of Opportunity in 1985 and confirmed for flight readiness in 1989. The TRW was selected as prime contractor for the mission, with major subcontracts to Eastman-Kodak, Hughes-Danbury, and Ball Aerospace. The Smithsonian Astronomical Observatory (SAO) also has significant involvement throughout the program. The MSFC, TRW, Hughes-Danbury and SAO were all part of the successful HEAO-2 program, which is a technical precursor of the AXAF program.

The AXAF was given new start approval in FY 1989, contingent on demonstrating the challenging advances in mirror metrology and polishing technology. The first pair of mirrors were fabricated and then tested in a specially designed X-ray Calibration Facility at MSFC in 1991. The x-ray test results validated the polishing and metrology. With the success of this Verification Engineering Test Article (VETA) #1 demonstration, the program proceeded fully into design and development (Phase C/D). The AXAF program was restructured in 1992 to reduce life-cycle program costs. The original baseline was an observatory with six mirror pairs which was planned for a fifteen-year mission in low Earth orbit with periodic Shuttle servicing required. The restructuring produced AXAF-I, an observatory with four mirror pairs to be launched into a

high Earth orbit for a five year life time, and a smaller observatory (AXAF-S) flying an X-Ray Spectrometer (XRS) from the original baseline. A panel from the National Academy of Sciences endorsed the restructured AXAF program.

With the FY 1994 Budget, AXAF-I development reached the half-way point in terms of funding, and is now at the peak annual level required to complete the program. Mirror development work at Hughes-Danbury is continuing, and the assembly facility for the High Resolution Mirror Assembly (HRMA) at Eastman-Kodak is now operational. NASA is proceeding with the decision to launch AXAF on the Shuttle; a contract for an upper stage is expected to be awarded in April of 1994.

BASIS OF FY 1995 ESTIMATE

Fiscal Year 1995 is a critical year for AXAF-I development activities. The Observatory Preliminary Design Review (PDR) is scheduled for November 1994, and detailed design of the AXAF spacecraft structure and instruments will continue throughout the year. Fabrication of the structural test model, VETA 2, begins in FY 1995 and will be completed by early FY 1996. A Critical Design Audit (CDA) of the Boeing-developed Optical Bench assembly will be held by TRW in September 1995. All flight mirrors are scheduled to be delivered later in the year, and initial mirror coating will begin in the May 1995 timeframe. All instrument Critical Design Reviews (CDRs) are scheduled for completion in FY 1995.

The FY 1995 budget does not include funding to continue development of the XRS instrument. However, studies are currently underway to determine instrument modifications and spacecraft interfaces. If upon completion of the joint U.S.-Japanese studies -- including assessments of scientific merit, schedule and funding requirements -- the joint program is determined to be scientifically meritorious and programmatically feasible, NASA will provide the results to the Congress and propose appropriate changes, if any, to the FY 1995 budget plan.

BASIS OF FY 1995 FUNDING REQUIREMENT

RELATIVITY MISSION DEVELOPMENT

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Shuttle test of relativity experiment...........	25,100	2,400	1,800
Gravity probe-b................................	1,900	40,000	48,200
Total....................................	27,000	42,400	50,000

OBJECTIVES AND STATUS

The Gravity Probe-B (GP-B) flight mission is a relativity experiment being developed for NASA by Stanford University. It is intended to test two extraordinary, unverified predictions of Einstein's general theory of relativity known as geodetic and frame dragging precession. To do this, very small changes in the direction of spin of four gyroscopes contained in a spacecraft, placed in a 640 km polar orbit, will be monitored. In order to make such a measure, extremely precise superconducting gyroscopes had to be developed. These gyroscopes must operate in a near absolute zero temperature environment, undisturbed by magnetic or drag forces, while maintaining an extraordinary accuracy during the experiment's lifetime of more than one year. These gyroscopes will measure how space and time are warped by the presence of the Earth and, more profoundly, how the Earth's rotation drags space-time around with it. These effects, though small for the Earth, have far reaching implications for our understanding of the nature of matter and the structure of the Universe. Although other experiments have been performed to confirm Einstein's general theory since it was developed in the early 20th century, they have provided only a weak verification of the theory. The GP-B will provide a much more stringent test, and will significantly add to the precision with which general relativistic effects are measured. Consequently, it has received the support of the Space Studies Board of the National Research Council since the early 1980's.

Results of the GP-B experiment promise to affect the study and interpretation of black holes, quasars, and other astrophysical systems. But more importantly, this unique experiment will test with unsurpassed precision Einstein's hypothesis of space-time curvature and will also measure for the first time one of the most fundamental untested consequences of general relativity, the "dragging" of space-time by rotating matter. Since Einstein's geometrical interpretation of gravitation is at odds with current theoretical ideas in other areas of physics, GP-B has the potential of making a major contribution to the knowledge required to arrive at a grand unification of the forces of nature.

In order for Stanford to develop gyroscopes capable of making measurements with the accuracy needed to monitor the effects predicted by the theory of General Relativity, several advances had to be made in the superconductivity, magnetic shielding, precision manufacturing, spacecraft control mechanisms, and cryogenics. Thus the GP-B spacecraft will employ super-precise quartz gyroscopes (small quartz spheres machined to an atomic level of smoothness); coated with a super-thin film of superconducting material (needed to be able to "read-out" changes in the direction of spin of the gyros); encased in an ultra-low magnetic-shielded, supercooled environment (requiring a complex process of lead-shielding, a large supercooled dewar, and a sophisticated interface among the instrument's telescope, the shielded instrument assembly, and the dewar); while maintaining a gyroscope level of precision of 0.2 milliarcseconds per year (the width of a human hair observed from 50 miles). This extreme measurement precision requires precise star-tracking, a "dragfree" spacecraft control system, and micro-precision thrusters.

Following NASA's 1984 review of the status of the GP-B experiment, and because of the sophistication of the technology required, NASA directed Stanford University to focus on ground test verification of GP-B technologies, via the Shuttle Test of Relativity Experiment (STORE) program prior to start-up of a GP-B flight program. Since then, prototype gyroscopes, telescope assemblies, a flight-like tube that surrounds the instrument and telescope, and a laboratory version of a dewar have been subjected to a first round of laboratory testing. Many subcomponent technologies have been designed and evaluated leading up to this initial verification test. Stanford University, working in collaboration with the Lockheed Palo Alto Research Laboratory (LPARL), has now either demonstrated or shown by calculation that the GP-B technologies are attainable. Consequently, the GP-B experiment was accepted as a flight mission in 1993.

The GP-B development is conducted by Stanford University in collaboration with LPARL for dewar development. Spacecraft development and integration will be performed by the Lockheed Missiles and Space Corporation, which was recently selected under a competitive procurement conducted by Stanford University. The MSFC provides technical and managerial support of the project and aids NASA Headquarters in its project oversight.

BASIS OF FY 1995 ESTIMATE

The schedule and funding for this program are currently under review. In order to maintain a launch date prior to the year 2000 within a level-of-effort funding profile in FY 1995 and beyond, it may be necessary to eliminate the STORE mission's Shuttle test flights and to change GP-B from a prototype to a protoflight development program. If this plan is approved, STORE funds in FY 1994-1995 supporting the Shuttle mission will then be applied to free-flyer development in order to allow for the earliest possible launch date. This plan change will probably be formally accepted in early 1994. Congress will be kept informed of any such changes.

BASIS OF FY 1995 FUNDING REQUIREMENT

GLOBAL GEOSPACE SCIENCE

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Global geospace science	72,647	*13,300	*--
Mission operations and data analysis	(2,110)	(12,000)	(22,400)
Launch vehicles	(2,100)	(16,300)	(--)

* Funding requirements under review

OBJECTIVES AND STATUS

The Global Geospace Science (GGS) program is part of the U.S. contribution to the International Solar Terrestrial Physics (ISTP) program. This program is an international, multi-spacecraft, collaborative science mission designed to provide the measurements necessary for a new and comprehensive understanding of the interaction between the sun and the Earth. The GGS makes the U.S. a full partner in the ISTP program, reinforcing our commitments to international cooperation and maintaining a leadership role in solar-terrestrial physics.

The GGS is a complementary science mission to the Collaborative Solar Terrestrial Research (COSTR) program under which NASA provides instruments and launch support in exchange for access to science data in a cooperative effort with the European Space Agency (ESA) and the Japanese Institute of Space and Aeronautical Science (ISAS). The combined ISTP program will include eight spacecraft: two U.S. spacecraft, Wind and Polar; five ESA spacecraft, including the Solar and Heliospheric Observatory (SOHO) and four Cluster spacecraft; and one ISAS spacecraft, Geotail. Launch of this suite of systems began in 1992 with the successful launch of Geotail and will be completed in 1995.

The GGS spacecraft, Wind and Polar, will combine their measurements with the Geotail satellite and other Earth observing satellites as the first phase of the ISTP program. The two U.S. spacecraft will use a total of nineteen instruments to make simultaneous measures of the interaction of the solar wind with the Earth's magnetic field, both at the head of the field and as the field surrounds the Earth. The GGS will provide the first coordinated geospace measurements of these key plasma source and storage regions, perform multi-spectral global auroral imaging, and provide multi-point study of the Earth's magnetic response to the solar wind. The GGS mission will enhance understanding of how energy and matter from the sun influences Earth's geospace and atmosphere, contributing to assessments of the relationship of the sun to the Earth's climate.

The GGS spacecraft contract was awarded to General Electric/Astro-Space Division (GE/ASD), now Martin-Marietta Corporation (MMC), in FY 1989, as was final confirmation and initiation of instrument development activity. The Wind instruments have been delivered, and mechanical and electrical integration are complete. The Polar instruments have also been delivered and are being integrated. Both spacecraft have begun comprehensive performance testing and have been scheduled for launch in 1994. Wind is currently scheduled for a launch in April or May; Polar is currently scheduled for launch in late Summer. Both missions will be launched aboard Delta II launch vehicles.

BASIS OF FY 1995 ESTIMATE

No development funds are requested in FY 1995 since both launches are currently baselined for FY 1994. Although current funding for the GGS program is adequate to support these launch dates, recent technical problems experienced during testing at the spacecraft contractor indicate that the current schedule will not be achievable. Current indications are that launches for Polar, and possibly Wind, could potentially slip into FY 1995. The program is currently under review to assess the technical, schedule and funding status and to determine the proper remedial actions required. Upon completion of this assessment, the agency will notify the Committees of revised launch dates and funding requirements in FY 1995.

BASIS OF FY 1995 FUNDING REQUIREMENT

PAYLOAD AND INSTRUMENT DEVELOPMENT

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Collaborative solar terrestrial research........	50,812	31,200	23,200
Tethered satellite system......................	1,500	2,400	3,800
Astrophysics payloads..........................	20,728	24,300	20,500
Space physics payloads.........................	1,200	1,600	400
Total..................................	74,240	59,500	47,900

OBJECTIVES AND STATUS

Instrument development activities support a wide range of instrumentation. Development funds support the design, integration and test of instruments for flight as Shuttle payloads or as flights of opportunity aboard domestic and international spacecraft. This line also supports prime mission operations and short-term data analysis activities for low-cost missions such as Shuttle payloads or low-cost/short-duration instrument flights of opportunity.

The Collaborative Solar Terrestrial Research (COSTR) program, in conjunction with NASA's GGS program, represents the U.S. contribution to the International Solar Terrestrial Physics (ISTP) program. Whereas the GGS program will deploy and operate two U.S. satellites, COSTR provides U.S. instruments for flight aboard foreign spacecraft. The latter includes the Solar and Heliospheric Observatory (SOHO), four Cluster spacecraft provided by the European Space Agency (ESA), and the Geotail mission developed by Japan. Geotail was successfully launched in July 1992 and mission operations are currently underway. The European SOHO and Cluster missions are scheduled for launch in July and December 1995, respectively. The SOHO will be launched aboard an Atlas IIAS spacecraft, while Cluster will be launched aboard an Ariane V.

In 1993, the baselined Multi-Anode Microchannel Array (MAMA) detectors experienced problems during qualification testing. These detectors are required for two of the five principal instruments to be flown on the SOHO mission -- the German Solar Ultraviolet Measurement of Emitted Radiation (SUMER) and the U.S. Ultraviolet Coronagraph Spectrometer (UVCS). NASA has determined that a substitute detector is required, and has terminated MAMA detector development at Ball Electro-Optic/Cryogenic Division. Development of a new Cross Delay-line (XDL) detector has been initiated in FY 1994.

The Tethered Satellite System (TSS) is an international cooperative project with the Italian government. The payload was flown aboard the Shuttle in July-August 1992. The objectives were to verify the engineering performance of the deployer, to understand the electromagnetic interaction between the tether/satellite/ Space Shuttle system and the ambient space plasma, to understand the dynamic forces acting upon a tethered satellite, and to develop the capability for future tether applications on the Space Shuttle and Space Station. Unfortunately, structural interference of a bolt limited deployment to only 256 meters as opposed to the ten kilometer deployment required to meet the mission objectives. In March 1993, a review committee was formed to assess the demand for tether systems applications and whether these would provide a useful addition to the NASA complement of experiment carriers. The committee determined that the unique capabilities of tether technology should be pursued, and that the TSS-1 mission should be reflown at the earliest possible date. Recent discussions with the Italians have therefore resulted in a planned reflight of the TSS mission aboard the Shuttle in early/mid 1996.

Funding for Astrophysics payloads supports development of several instruments designed for flight on the Space Shuttle, including the Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer (ORFEUS) and Interstellar Medium Absorption Profile Spectrograph (IMAPS), to be flown on the German-U.S. Shuttle Pallet Satellite (SPAS) in late 1995/early 1996: Astro-2 in December 1994, a reflight of the ultraviolet portion of the Astro-1 mission: and the Infrared Telescope in Space (IRTS), a joint U.S.-Japanese mission which will be launched in 1995 on an expendable launch vehicle and later recovered by the Shuttle.

The Astrophysics program also supports a number of ongoing international and U.S. development projects. These include the High Energy Transient Experiment (HETE, 1994), a small satellite for study of gamma-ray burst phenomena in multiple wavelengths: ground-based support for Japan's Very Long Baseline Interferometry Space Observatory Program (VSOP, 1996) and Russia's RADIOASTRON (1997) program: the Stellar X-ray Polarimeter (SXRP) instrument to be flown on Russia's Spectrum-X-Gamma (SXG, 1995) mission; U.S. cooperation on the Infrared Space Observatory (ISO, 1995), a European follow-on to the Infrared Astronomical Satellite (IRAS, 1983); and portions of two instruments to be flown on Europe's X-ray Mirror Mission (XMM, 1998).

Space Physics payloads funding in FY 1993 was used to complete activities on the Atmospheric Laboratory for Applications and Science (ATLAS-1, 1992). The small level of continuing funds in FY 1994-95 for Space Physics payloads will be used to develop instruments for future flight opportunities aboard U.S. and foreign spacecraft.

BASIS OF FY 1995 ESTIMATE

The COSTR program will provide continuing support for development of the joint ESA-U.S. SOHO and Cluster missions. All flight model instruments for both the SOHO and Cluster missions will be delivered by mid-FY 1994. Development and testing of the new Cross Delay-line (XDL) detectors will be completed by late FY 1994. The XDL flight units for the SOHO instruments, the German-built Solar Ultraviolet Measurement of

Emitted Radiation (SUMER) and the U.S. Ultraviolet Coronagraph Spectrometer (UVCS), are scheduled for delivery/retrofit in late FY 1994 and early FY 1995. Final spacecraft/instrument integration and test activities will be conducted in Europe prior to launch. The SOHO is scheduled for launch in July 1995 aboard an Atlas IIAS, and Cluster is scheduled for launch in December 1995 aboard an Ariane V.

Funds are also included in FY 1995 for ongoing science and mission support of the TSS reflight mission in early/mid 1996. These activities include refurbishment of instruments, mission planning, participation in mission simulations and analysis of environmental impacts from the other payloads aboard the same flight. Within Astrophysics payloads, FY 1995 funding will support shuttle reflights of the ORFEUS, IMAPS, and Astro instruments, as well as ongoing support for the Space Very Long Baseline Interferometry (SVLBI) subnet and the XMM and IRTS missions. The Russian SXG and European ISO spacecraft are expected to be launched in FY 1995. Post-flight data analysis for the HETE mission will continue through FY 1995.

Space Physics payloads support will initiate development of instruments for future flight opportunities.

BASIS OF FY 1995 FUNDING REQUIREMENT

EXPLORER DEVELOPMENT

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
X-ray timing explorer	65,402	36,900	36,700
Advanced composition explorer	--	33,200	44,100
Small explorers	36,646	39,400	33,100
Other explorers	13,784	13,800	6,500
Total	115,832	123,300	120,400

OBJECTIVES AND STATUS

Investigations selected for Explorer projects typically have highly specific objectives which do not require the capabilities of a major observatory. Past explorers have discovered radiation trapped within the Earth's magnetic field, investigated the solar wind and its interaction with the Earth, studied upper atmosphere dynamics and chemistry, mapped our galaxy in radio waves and gamma rays, and determined properties of the interstellar medium through ultraviolet observations. Explorers have performed active plasma experiments on the magnetosphere, made in-situ measurements of the comet Giacobini-Zinner, and completed the first high-sensitivity, all-sky survey in the infrared, discovering over 300,000 sources.

Two Delta-class missions, the X-ray Timing Explorer (XTE, 1995) and Advanced Composition Explorer (ACE, 1997), and two Small Explorer (SMEX) missions, the Fast Auroral Snapshot Explorer (FAST, 1994) and the Submillimeter Wave Astronomy Satellite (SWAS, 1995), are currently under development. All missions are managed by the Goddard Space Flight Center (GSFC). A majority of the spacecraft and some instrument payload development activities are therefore conducted with in-house civil servants. These personnel are actively engaged in ongoing hardware design, development, mission management, etc.

The XTE will conduct timing studies of x-ray sources. This will provide a comprehensive record of the source of x-rays with varying intensity over time, characterization of those attributes, and study of compact x-ray emitting objects such as binary stellar masses will be performed. The XTE spacecraft and Proportional Counter Array (PCA) instrument are being developed in-house at GSFC. The High Energy X-ray Timing Experiment (HEXTE) is being developed at the University of California, San Diego. The All Sky Monitor instrument is provided by the Massachusetts Institute of Technology (MIT). In FY 1994, flight instrument and spacecraft hardware integration will be completed and environmental testing will begin in preparation for launch as early as August 1995.

The ACE mission is a space physics mission that will use nine instruments to study the composition of the solar corona, interplanetary and interstellar media, and galactic matter across a wide range of plasma phenomena. The instruments include six high-resolution spectrometers designed to study the mass and charge of plasma phenomena. Three other instruments will provide measures of the lower energy phenomena related to the solar wind. The spacecraft is being developed by the Applied Physics Laboratory (APL). Instruments development is managed by the California Institute of Technology (CIT). The Preliminary Design Review (PDR) was completed in November 1993 and the Critical Design Review (CDR) is scheduled for late FY 1994. All ACE subsystems are to be delivered by September 1996 in preparation for a launch as early as August 1997 aboard a Delta II launch vehicle.

The FAST mission will provide high resolution data on the Earth's aurora and how electrical and magnetic forces control them. The flow of electrons, protons, and other ions will be studied with greater sensitivity, spatial resolution and faster sampling than ever before, using five small instruments. The FAST data will be integrated with the results of other Earth observing satellites and ground observations. The SWAS will provide discrete spectral data for study of the water, molecular oxygen, and carbon monoxide in dense interstellar clouds, the presence of which is related to the stability of these clouds. Both the FAST and SWAS are being developed in-house at the GSFC. The FAST spacecraft is nearly fully integrated and instrument deliveries are forthcoming in support of a launch in September 1994. The CDR for SWAS was completed in late 1993. Detailed design and initial hardware fabrication are currently underway in support of a planned launch in June 1995. Both missions will be launched aboard Pegasus launch vehicles. In September 1993, NASA selected four future Small Explorer (SMEX) missions for further definition. By mid-late 1994, it is expected that two of these missions will be confirmed for development leading to launches in 1997 and 1998.

BASIS OF FY 1995 ESTIMATE

Development activities on the XTE mission will continue in preparation for launch. Instruments and spacecraft components will be integrated onto the observatory throughout 1994. Final integration and environmental testing will be completed by mid-1995. A Pre-Ship Review (PSR) is scheduled for May prior to a June shipment to the Kennedy Space Center (KSC) for final integration and checkout. Launch is planned as early as August 1995 aboard a Delta II launch vehicle.

The FY 1995 estimate will also support the continuation of hardware fabrication and assembly of the ACE spacecraft and instruments. All ACE subsystems are to be delivered by September 1996 in preparation for a launch in August 1997 aboard a Delta II launch vehicle.

The SMEX missions, FAST and SWAS, will be launched in September 1994 and June 1995, respectively. Final development activities and launch preparation for the SWAS mission will continue in FY 1995 in preparation

for launch and initial mission operations. Selection of two future SMEX missions will be completed by mid-late 1994, and development of the next SMEX mission will begin in FY 1995.

BASIS OF FY 1995 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
AXAF mission operations and data analysis	14,900	11,600	18,900
Hubble space telescope operations and servicing	216,676	219,400	226,700
Hubble space telescope data analysis	42,357	38,500	42,700
Astrophysics mission operations and data analysis	88,268	84,500	89,000
Space physics mission operations and data analysis	53,201	66,700	64,400
Total	415,402	420,700	441,700

OBJECTIVES AND STATUS

The Mission Operations and Data Analysis (MO&DA) program supports the prime missions of astrophysics and space physics spacecraft, and ongoing analysis of selected mission data sets. For major missions such as AXAF and HST, funding is also applied to pre-launch preparations for operations and data analysis activities, and for long-term data archiving and data base services. In addition, funds from this category are used to support future servicing missions for the Hubble Space Telescope (HST).

Pre-launch operations funding for the Advanced X-ray Astrophysics Facility (AXAF) program supports the development of a ground control system, science center and preparations for flight system operation. A common ground system located at the Marshall Space Flight Center (MSFC) will be used to serve the combined requirements for the Space Shuttle, Spacelab, and AXAF flight operations. The AXAF mission operations will also be supported by an AXAF Science Center located at the Smithsonian Astronomical Observatory (SAO), a division of the Massachusetts Institute of Technology (MIT).

The Hubble Space Telescope (HST) science operations are conducted via the HST Science Institute which operates under a long-term contract with NASA. Satellite operations, including telemetry, flight operations, and initial science data transcription, are performed on-site at Goddard Space Flight Center (GSFC) under a separate contract. While NASA retains operational responsibility for the observatory, the Science Institute plans, manages, and schedules the scientific operations of the HST. In a single year of

operations, the activities of over 500 scientists are supported under the HST program, and over 15,000 observations have been recorded.

In order to extend its operational life and provide a basis for future enhancements of its scientific capabilities, the HST is designed to be serviceable. This requires on-orbit maintenance and change-out of spacecraft subsystems and scientific instruments every few years. In December 1993, the first HST servicing mission was performed to restore the faint object and crowded field capabilities of the telescope, which had been unavailable due to spherical aberration of the primary mirror. Also, jitter induced by thermal effects on the solar arrays was corrected by the installation of two modified solar arrays provided by the European Space Agency (ESA). Several subsystems, including rate gyroscopes, magnetometers, and additional computer memory, were installed so as to restore redundancy and to ensure operations until the next servicing mission.

The HST funds also support planning and development of instruments for future servicing missions and for development of other components critical to the reliability of the HST. Two new instruments, the Space Telescope Imaging Spectrometer (STIS) and the Near Infrared Camera/Multi-Object Spectrometer (NIC/MOS), are currently under development for the next servicing mission currently planned for March/April of 1997. Both STIS and NIC/MOS are being developed by Ball Aerospace Division (BASD). Both instruments have Critical Design Reviews (CDRs) planned for mid-1994. Other hardware, such as batteries, gyroscopes, and an Advanced Camera are under consideration for a servicing mission in 1999. Ongoing modification and upkeep of ground systems operations are also performed.

Other satellites developed wholly or in part by NASA are also supported under the Astrophysics and Space Physics mission operations and data analysis programs. Currently, six operational missions in astrophysics and seven operational missions in space physics are supported. Astrophysics missions include the Compton Gamma-Ray Observatory (CGRO, 1991), the Extreme Ultraviolet Explorer (EUVE, 1992), the Cosmic Background Explorer (COBE, 1989), the International Ultraviolet Explorer (IUE, 1978), and U.S. participation in the German Roentgen Satellite (ROSAT, 1990) and the Japanese Astro-D/ASCA (1993). Space physics missions include Voyager 1 and 2 (1977), Ulysses (1990), Pioneer 10 and 11 (1972,73), the Interplanetary Monitoring Platform (IMP-8, 1973), the Solar, Anomalous Magnetospheric Particle Explorer (SAMPEX, 1992), and the Japanese cooperative missions, Yohkoh (1991) and Geotail (1992).

The CGRO measures gamma-rays, providing unique information on phenomena occurring in quasars, active galaxies, black holes, neutron stars, supernova, and the nature of the mysterious cosmic gamma-ray bursts. The EUVE is studying the sky at wavelengths once believed to be completely absorbed by the thin gas between the stars. The COBE has provided dramatic scientific evidence confirming the Big Bang theory and has measured the isotropy of the cosmic background radiation to better than one part in 100,000 over the entire sky. The IUE continues to provide valuable data in ultraviolet wavelengths for U.S. and European scientists. The U.S. observers continue to enjoy 50% of the observing time, shared with Germany and the

United Kingdom (U.K.), from the highly successful ROSAT X-ray satellite. The Japanese/U.S. Astro-D/ASCA spacecraft is conducting spatially-resolved spectroscopic observations of selected cosmic x-ray sources. The Interplanetary Monitoring Platform (IMP-8) provides the only measure of solar wind input to the Earth. The Yohkoh spacecraft, a cooperative program with the Japanese, is continuing to gather x-ray and spectroscopic data on solar flares, irradiance, and oscillations. Ulysses is on its way to study the sun's polar regions, measuring the interplanetary medium and solar wind as a function of heliographic latitude, having been swung out of the plane of the ecliptic by the gravity of Jupiter. Voyager 1 and 2 and Pioneer 10 and 11 are continuing to look for the heliospheric boundary with interstellar space as they travel beyond the planets. The SAMPEX is measuring the composition of solar energetic particles, anomalous cosmic rays, and galactic cosmic rays. Geotail, a Japanese spacecraft which is the first part of the cooperative International Solar Terrestrial Physics (ISTP) program, is studying the Earth's magnetotail.

In Astrophysics MO&DA, mission operations continue for IUE, HST, ROSAT, CGRO, EUVE and Astro-D/ASCA through FY 1994. Science operations of COBE have ceased. Data archival and analysis activities continue, and the spacecraft continues to be used in training activities. This phenomenally successful spacecraft had a design life of one year, but has continued to perform all-sky microwave surveys after exhausting its cryogen supply. Analysis and archival of data from the High Energy Astrophysics Observatory (HEAO) will be completed at the end of FY 1994 since the primary science objectives will have been met. Data analysis of the Astro-C/Ginga mission will also be completed in FY 1994.

In Space Physics MO&DA, operations and data analysis will continue for Ulysses, SAMPEX, Geotail, Yohkoh, IMP-8 and Voyager. Ongoing mission support is also provided for the Pioneer missions, although Pioneer 11 operations may be terminated during FY 1994 due to the decreasing power supply on board the spacecraft. Several new spacecraft are scheduled for launch in FY 1994, including the GGS spacecraft, Wind and Polar, and the Fast Auroral Snapshot (FAST) mission, the second of the Small Explorer (SMEX) missions developed within the Explorer program.

BASIS OF FY 1995 ESTIMATE

The AXAF MO&DA funds will support ongoing development of ground system elements and documentation of ground control operations. Critical Design Reviews (CDRs) of the Operations Control Center and the AXAF Science Center are also planned.

The HST operations and servicing funds will support preparations for future servicing missions, ongoing development of ground systems and ground system operations, and ongoing mission operations for the Hubble system. Hardware fabrication and integration of the NIC and STIS instruments will be performed throughout FY 1995 in support of the 1997 servicing mission. Development and maintenance of components and subsystems for future telescope maintenance is also planned. Maintenance of flight system and ground system software, hardware, and operations protocols will also continue. The HST data analysis funds will sustain the

Guaranteed Time Observers program, composed of science instrument teams for the current set of HST instruments; and expansion of the Guest Observer and Archival Researchers programs.

Astrophysics MO&DA will continue operations and data analysis activities for the CGRO, EUVE, IUE, ROSAT and Astro-D/ASCA missions. The COBE mission operations are discontinued in FY 1994, and data analysis activities will be completed in FY 1995. The recently developed Astrophysics Data System and other archiving systems will continue to provide scientific users access to NASA's astrophysics data. Funds are also provided to support ongoing data analysis of existing data sets from previous missions.

Space Physics MO&DA will continue to support ongoing mission operations and data analysis for the Pioneer, Voyager, Ulysses, IMP-8, Geotail, SAMPEX and Yohkoh missions. Funds are also provided to support the new Wind, Polar and FAST missions launched in 1994. Initial mission operations for the Solar Heliospheric Observatory (SOHO) mission will also begin following a launch in July 1995.

BASIS OF FY 1995 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Space physics supporting research and technology	37,257	35,700	35,700
Astrophysics supporting research and technology	34,301	35,400	35,400
Total	71,558	71,100	71,100

OBJECTIVES AND STATUS

The objectives of the Supporting Research and Technology (SR&T) program are to: (1) optimize the design of future missions through science definition, development of advanced instruments and concepts, and definition of proposed new missions; (2) strengthen the technological base for sensor and instrument development; (3) enhance the value of current space missions by carrying out ground-based observations and laboratory experiments; (4) conduct basic research necessary to understand astrophysics phenomena and solar-terrestrial relationships and develop theories to explain observed phenomena and predict new ones; and (5) continue the acquisition, archival, analysis and evaluation of data from laboratories, airborne observatories, balloons, rocket and spacecraft missions.

The SR&T program carries out its objectives through providing grants to universities, nonprofit and industrial research institutions, and funds to scientists at NASA Centers and other government agencies. Several hundred grants are awarded each year to the U.S. science community. These grants help train science and engineering graduate and post-graduate students who will become the nation's future scientific leaders.

Astrophysics SR&T supports research activities in the areas of gamma-ray, x-ray, ultraviolet, visible light, infrared, submillimeter, and radio astrophysics. Both the Explorer and Great Observatories programs rely upon accomplishments of the SR&T program for technology development and instrument design to achieve planned science objectives. Current emphasis is being placed on studies of advanced instruments and detectors with increased sensitivity and resolution.

Space Physics SR&T supports researchers in the disciplines of magnetospheric, ionospheric, cosmic ray, heliospheric, plasma and solar physics. This broadly structured program enhances our understanding of plasmas in the solar corona, interplanetary medium, geospace and other planets. Recent studies of the near-

Earth geospace environment have many practical implications, such as determining disruptive effects on communications, analyzing the impact on global circulation of the Earth's upper atmosphere, or examining space plasma effects on spacecraft.

NASA also allocates SR&T funds to Advanced Technology Development (ATD) programs. Increasing emphasis is being made within the agency to better utilize advanced technologies in future missions. The ATD is used to develop new mission concepts and ensure that mission technologies are sufficiently mature before development begins to minimize cost, schedule, and technical risks. Mission concept and definition studies identify new technologies and optimize their use within an affordable development cost.

BASIS OF FY 1995 ESTIMATE

The Astrophysics ATD program will continue to support definition studies for the Stratospheric Observatory for Infrared Astronomy (SOFIA), an airborne-observatory intended to replace the current NASA airborne astronomy system, and technology studies for future space infrared astronomy missions. Ongoing support for grant-funded studies in gamma-ray, x-ray, ultraviolet, visible light, infrared, submillimeter, and radio astrophysics will also continue.

Space Physics SR&T activities include continuing definition studies of missions emphasizing the use of small spacecraft and rapid development. These include the Thermosphere, Ionosphere, Mesosphere Energetic and Dynamics (TIMED), the High Energy Solar Physics (HESP), and the Solar Probe missions. Ongoing support for grant-funded studies in magnetospheric, ionospheric, cosmic ray, heliospheric, plasma and solar physics will also continue.

BASIS OF FY 1995 FUNDING REQUIREMENT

SUBORBITAL PROGRAM

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Airborne program	13,014	13,600	13,200
Balloon program	15,437	16,400	16,000
Sounding rockets	36,392	39,500	38,000
Total	64,843	69,500	67,200

OBJECTIVES AND STATUS

The suborbital program uses aircraft, balloons, and sounding rockets to conduct versatile, relatively low-cost research of the Earth's ionosphere and magnetosphere, space plasma physics, stellar astronomy, solar astronomy, and high energy astrophysics. Activities are conducted on both a national and international cooperative basis.

The Airborne science and applications program operates the Kuiper Airborne Observatory (KAO) for astronomy research. The KAO facility consists of a C-141 aircraft equipped with a 91-centimeter infrared telescope, managed by the Ames Research Center (ARC). The C-141's ability to fly for several hours at altitudes approaching thirteen kilometers enables routine access to infrared observations which would not otherwise be possible due to atmospheric water vapor at lower altitudes. The infrared region of the electromagnetic spectrum extends from wavelengths of one micrometer to approximately one millimeter. The KAO is currently the only airborne facility in the world that can conduct observations in the far infrared and submillimeter wavelengths and is continuing to provide important scientific observations of a wide variety of objects, including star formations in the Milky Way, activity in the nucleus of the Milky Way, and planets and moons in the solar system. In 1993 the KAO flew 82 times, with a total flight time of 518 hours. Approximately 75-80 flights are planned for FY 1994, including a special program to observe the impact of comet P/Shomaker-Levy 9 with the planet Jupiter in mid-July.

The Balloon program, managed by the Wallops Flight Facility (WFF), provides a cost-effective means to test flight instrumentation in the space radiation environment and to make observations at altitudes which are above most of the water vapor in the atmosphere. In many instances it is necessary to fly primary scientific experiments on balloons, because of size, weight, or cost considerations or lack of other opportunities. Balloon experimentation is particularly useful when studying infrared, gamma-ray, and cosmic-ray astronomy. In addition to the level-of-effort science observations program, the program has

successfully developed balloons capable of lifting payloads greater than 5,000 pounds. In addition, the balloon program is now capable of conducting a limited number of missions lasting nine to fourteen days; successful long-duration flights have been conducted in the Antarctic, and more are planned. In 1993, the Balloon program flew 34 missions. Approximately 35 missions are planned for FY 1994.

The Sounding Rocket program is managed by Goddard Space Flight Center (GSFC), in conjunction with the Wallops Flight Facility (WFF). Sounding rockets are uniquely suited for performing low altitude measurements (between balloon and spacecraft altitude) and for measuring vertical variations of many atmospheric parameters. Special areas of study supported by the sounding rocket program include the nature, characteristics, and composition of the magnetosphere and near space; the effects of incoming energetic particles and solar radiation on the magnetosphere, including the production of aurora and the coupling of energy into the atmosphere; and the nature, characteristics, and spectra of radiation of the sun, stars and other celestial objects. The program also provides the means for flight testing instruments being developed for future flight missions, calibrating flight instruments and obtaining vertical atmospheric profiles to complement data obtained from orbiting spacecraft. Funding for Sounding Rockets typically supports up to 35 rocket flights per year.

Support for Spartan missions aboard the Shuttle is also included within the Sounding Rockets budget. Spartan 201 consists of a 17-inch diameter solar telescope with an ultraviolet coronagraph and a white light coronagraph to observe and measure the solar source of the solar wind. Spartan 201 had a highly successful flight in 1993, and reflights are planned for 1994 and 1995 to provide correlative data for the Ulysses mission during its passage over the solar poles.

BASIS OF FY 1995 ESTIMATE

In FY 1995, Airborne funds will support ongoing logistics and periodic maintenance requirements for the KAO aircraft at Ames. The program typically provides 70-80 flight opportunities per year, although extensive maintenance and inspections to be conducted during late FY 1994 through the first quarter of FY 1995 has reduced the planned flight rate to about 50 missions.

The Balloon program typically provides over 35 flight opportunities per year. In support of these missions, ongoing maintenance and operations of the National Scientific Balloon Facility (NSBF) at Palestine, Texas, and other remote launch sites are also required.

Sounding rocket flights will also be conducted for instrument testing, calibration and observations to complement data from orbiting spacecraft. The FY 1995 funds will be used to provide vehicles, hardware, integration, launch site support and maintenance for up to 35 flight opportunities. Support is also included within the Sounding Rockets budget for reflight of Spartan 201 aboard the Shuttle in late 1995.

BASIS OF FY 1995 FUNDING REQUIREMENT

INFORMATION SYSTEMS

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Information systems..........................	25,002	26,500	26,100

OBJECTIVES AND STATUS

The Information Systems program provides a state-of-the-art environment to support science research objectives. This includes high performance networking and computing, and an interactive analysis environment with expedient access to data, mathematical processes tools, and advanced visualization techniques. Multiple science disciplines are supported by the projects funded under this program.

NASA's National Space Science Data Center (NSSDC) archives and distributes data acquired in space flight programs. A master directory service for distribution of science data to a wide range of users is also maintained. In addition, support is provided for development of search techniques to access data from multiple data bases and to assimilate data from multiple data sets into single applications.

The NASA Science Internet (NSI) is a computer networking service used to provide access to flight program data bases, data processing systems, and to applications for scientific collaboration. Researchers and organizations participating in NASA-funded flight programs and in joint international missions are supported by this capability. This capability is closely coordinated with other U.S. computer networking facilities.

Funds provided for information system research and technology are used to improve science data management, analysis, and visualization techniques to improve scientists' productivity.

BASIS OF FY 1995 ESTIMATE

The FY 1995 funding will continue operation of the NSSDC to distribute science data assets. Continued development of master directory services and data exchange standards for enhanced inter-operability among data bases will be emphasized. The NSI will continue to support science data networking needs, providing access to the network responsive to user requirements. Research and technology efforts will continue to seek improved visualization methods and capabilities. The FY 1995 funding requested is less than the FY 1994 appropriated level. Services provided by the NSSDC and NSI will continue at approximately the same level as FY 1994, although investment in advanced technologies such as visualization tools and technology testbeds will be tightly constrained.

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1995 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

PLANETARY EXPLORATION

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1993	FY 1994	FY 1995	Page Number
		(Thousands of dollars)		
Mars '94	3,500	3,500	1,400	SAT 1.2-5
Cassini development	204,953	266,600	255,000	SAT 1.2-6
Discovery development	--	127,400	129,700	SAT 1.2-8
Mars surveyor program	--	(10,300)	78,400	SAT 1.2-10
Mission operations and data analysis	163,465	141,700	127,700	SAT 1.2-12
Research and analysis	101,680	115,100	115,100	SAT 1.2-14
Construction of facilities	2,000	--	--	
Total	475,598	654,300	707,300	

Distribution of Program Amount by Installation

	FY 1993	FY 1994	FY 1995
Johnson Space Center	13,700	3,677	3,347
Marshall Space Flight Center	1,000	--	--
Langley Research Center	713	--	--
Ames Research Center	10,632	5,744	3,008
Goddard Space Flight Center	24,575	19,042	25,164
Jet Propulsion Laboratory	311,400	487,279	560,450
Headquarters	113,578	138,558	115,331
Total	475,598	654,300	707,300

OBJECTIVES AND JUSTIFICATION

The Planetary Exploration program encompasses the scientific exploration of the solar system including the planets and their satellites, comets and asteroids, and the interplanetary medium. The program objectives are: (1) to determine the nature of planets, comets, and asteroids as a means for understanding the origin and evolution of the solar system; (2) to understand the Earth better through comparative studies with the other planets; (3) to understand how the appearance of life in the solar system is related to the chemical history of the solar system; and (4) to provide a scientific basis for the future use of resources available in near-Earth space. Projects undertaken in the past have been highly successful based on a strategy that places a balanced emphasis on the Earth-like inner planets, the giant gaseous outer planets, and the smaller bodies (comets and asteroids). Missions to previously unexplored solar system bodies typically are at the reconnaissance level to achieve a fundamental characterization of the target of observation. Subsequent missions to the same bodies are then enabled to conduct more detailed studies.

With the Magellan mapping of the Venusian terrain, the reconnaissance phase of inner planetary exploration, with the exception of Mercury, is virtually complete. Magellan was launched in April 1989 and arrived at Venus in August 1990. Using a Synthetic Aperture Radar (SAR) to penetrate the planet's opaque atmosphere, the spacecraft provided high resolution data sufficient to identify small-scale topographical features that address fundamental questions about the origin and evolution of the planet. Radar and altimetry data acquisition was completed in FY 1992, providing a global map of 99% of the Venusian surface. In FY 1993, the spacecraft completed a series of aerobraking maneuvers to circularize the orbit and is currently collecting high resolution gravity data which will yield significant information on the interior structure of the planet.

Mars has been a primary program focus due to its potential for previous biological activity and for comparative studies with Earth. The Mars Observer mission was launched in September 1992 and arrived at Mars in August 1993. Unfortunately, communications with the spacecraft were lost just prior to orbit insertion. NASA is currently reassessing its Mars Exploration strategy with the proposed Mars Surveyor program. This is a series of small missions designed to resume the detailed exploration of Mars. The program will begin in FY 1994 with the development of a Mars Orbiter for remote sensing which will capture much of the data that would have been obtained from the Mars Observer mission. This is succeeded by a series of small communications orbiters and soft landers designed to obtain in-situ measurements on the

Martian surface. In FY 1993-94, funding is also provided to develop instruments which will fly aboard the two Russian Mars '94 landers.

Building upon the profound discoveries of the Pioneer and Voyager missions, Galileo will conduct detailed studies of the planet Jupiter and its satellites. Galileo was launched in October 1989 and encountered Gaspra in October 1991, obtaining the first detailed images ever of an asteroid. In August 1993, the spacecraft provided higher resolution images of a second asteroid, Ida, as it flew by en route to Jupiter. Upon arrival at Jupiter in December 1995, the spacecraft will conduct twenty-two months of prime mission operations. Galileo will inject its instrumented probe into Jupiter's atmosphere to make in-situ measurements while the orbiter will have the capability to make as many as ten close encounters with the Galilean satellites.

Cassini will conduct extensive investigations of Saturn, its rings, and its satellites. In conjunction with spacecraft observations, the European Space Agency (ESA)-provided Huygens Probe will conduct in-situ atmospheric measurements of Saturn's moon Titan. Also building upon the discoveries made through the Pioneer and Voyager missions, Cassini will provide new insight into the origin of the solar system and will help determine whether the necessary building blocks for the chemical evolution of life exist elsewhere in the universe. In an effort to reduce total program costs and improve mass and schedule margins, the program was restructured in 1992. Despite significant changes to the spacecraft design, the science payload remains essentially intact. Development activities are currently underway with the launch scheduled for October 1997 aboard a Titan IV launch vehicle. En route to Saturn, the spacecraft will fly by Earth, Venus, and Jupiter to gain sufficient acceleration to reach Saturn in June 2004. Upon arrival, the spacecraft will conduct extensive investigations of the Saturnian system for four years.

Funding was provided in FY 1994 for the start of the first two Discovery missions, the Mars Environmental Survey (MESUR) Pathfinder and the Near Earth Asteroid Rendezvous (NEAR). Pathfinder will test innovative entry, descent and landing systems, and will deliver a modest science payload to the Martian surface, including a microrover provided by the Office Of Advanced Concepts and Technology (OACT). Pathfinder will collect spacecraft performance data during these activities as well as atmospheric pressure, temperature and density information. Pathfinder is being built by the Jet Propulsion Laboratory (JPL) and will launch in December 1996 aboard a Delta II launch vehicle. The NEAR promises to answer fundamental questions about the nature and origin of "primitive bodies" in its one year orbit about the asteroid 433 EROS. The NEAR is being built by the Applied Physics Laboratory, and will launch in February 1996 aboard a Delta II launch vehicle.

In addition to the development of new missions, ongoing Mission Operations and Data Analysis (MO&DA) activities are a major focus of the Planetary Exploration program. Activities include the monitoring of spacecraft operations, ongoing mission design and software development, and acquisition/processing/analysis of new data as it is acquired. Ongoing analysis of existing data sets are also conducted. Extensive effort

continues to support Galileo and Magellan. Upon completion of high resolution gravity measurements, Magellan mission operations are planned for termination by the end of FY 1994. Galileo operations and ground system developments continue as the spacecraft nears Jupiter. Failure to fully deploy the High Gain Antenna (HGA) has required the mission to be conducted using only the Low Gain Antenna (LGA) for spacecraft telemetry and data downlink. Design and development of system changes are also currently underway to support the new mission approach. Funding is also provided to support the Mission Operations Support Office (MOSO) at JPL. This facility provides continuous design, development and maintenance of ground support hardware and software for mission control, telemetry and command functions for all planetary spacecraft still in operation.

The Research and Analysis (R&A) program continues to define the scientific priorities for future missions as well as maximizing the exploitation of existing data sets. Funds are provided on an annual basis to support grants to universities and other participants for basic and applied research across a variety of planetary science disciplines. Advanced program funding supports the definition of future planetary missions. Funds are also provided for definition of new science instruments to ensure maximum scientific return from future missions. Per Congressional direction, the High Resolution Microwave Survey (HRMS) program was terminated in FY 1994.

BASIS OF FY 1995 FUNDING REQUIREMENT

MARS '94

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Mars '94	3,500	3,500	1,400

OBJECTIVES AND STATUS

Mars '94 is a Russian mission comprised of an orbiter and two hard landers which will be deployed on the Martian surface. Each lander will carry a variety of science instruments provided by several international partners including Germany, Finland and France as well as the U.S. These include descent and surface imagery, in-situ seismology, soil composition, and meteorology measurements.

The Jet Propulsion Laboratory (JPL) will provide two Mars Oxidation (MOx) experiments, one for flight aboard each of the two original landers. To conserve mass, power, and space, these experiments will share common electronics subsystems with German and Russian instruments. These instruments will determine the presence of atmospheric and/or soil oxidants which theoretically caused the rapid destruction of the organic material tested on the Viking mission. U.S. scientists are also involved on many of the other science instruments provided by our foreign partners.

Final integration and testing of the two U.S. science instruments is nearing completion. Shipment of the flight units to Russia is planned for late January/early February for integration with the rest of the science payload. The science hardware will then be shipped to Babakin, the Russian launch facility, in April 1994 for final integration and testing with the Russian spacecraft. The scheduled launch date is October 1994 aboard a Russian Proton launch vehicle. The 1-year prime mission will begin upon arrival at Mars in September 1995.

BASIS OF FY 1995 ESTIMATE

The FY 1995 funding provides ongoing support for the U.S. science investigators associated with all aspects of the science payload. The JPL has also been designated to handle data processing and dissemination of all data from the Mars '94 mission. The FY 1995 funding is therefore provided to establish science data formatting, archival and dissemination requirements prior to initiation of the prime mission in September 1995.

BASIS OF FY 1995 FUNDING REQUIREMENT

CASSINI DEVELOPMENT

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Cassini development	204,953	266,600	255,000
Launch vehicle	(5,300)	(86,400)	(91,300)

OBJECTIVES AND STATUS

During the 1970's, our Nation established scientific and technological leadership in exploration of the outer solar system with successful launches of Pioneers 10 and 11 and Voyagers 1 and 2. The Cassini mission will maintain our leadership in solar system exploration. Building upon the earlier discoveries of Pioneer and Voyager, Cassini's study of the Saturnian system will greatly improve our understanding of the early evolutionary processes which formed our entire solar system. The Cassini targets (Titan and the Saturn system) have a common origin in the outer solar system. The icy conditions on these bodies preserve a record of different stages and processes occurring during solar system formation and evolution. Analysis of their structure and composition may help determine whether the necessary building blocks for the chemical evolution of life exist elsewhere in the universe. In conjunction with Galileo's study of the Jovian system, the mission should also provide much insight as to how and why the large, gaseous outer planets have evolved much differently than the inner solar system bodies.

Cassini is scheduled for launch in October 1997 aboard a Titan IV launch vehicle. An extensive cruise period is required to reach Saturn, requiring the spacecraft to fly by Venus, Earth, and Jupiter to gain sufficient velocity to reach its destination. Upon arrival in June 2004, the spacecraft will begin four years of study of the Saturnian system which will provide intensive, long-term observations of Saturn's atmosphere, rings, magnetic field, and moons. In conjunction with the observations conducted by the spacecraft, the European Space Agency (ESA)-provided Huygens Probe will be injected into the atmosphere of Saturn's moon Titan, to conduct in-situ physical and chemical analyses of its methane-rich, nitrogen atmosphere which is a possible model for the pre-biotic stage of the Earth's atmosphere. The Cassini spacecraft will also obtain a radar map of most of Titan's surface.

In an effort to reduce total program costs and improve mass and schedule margins, the Cassini mission was restructured in 1992. Despite significant changes to the spacecraft design, the science payload remains essentially intact. Since that time, significant progress has been made to incorporate these changes into the mission design. In FY 1993, the spacecraft Critical Design Review (CDR) and an overall Technical Progress Review were conducted, and all major spacecraft and instrument activities appear to be on schedule

at this time. In FY 1994, subsystem level CDRs will be conducted for several major spacecraft subsystems. Spacecraft subsystem level assembly and test activities will also begin, leading to initial subsystem level integration activities by early FY 1995. Instrument detailed design activities will continue throughout FY 1994, leading to a CDR by early FY 1995. The ESA will also conduct a Hardware Design Review for the Huygens Probe. A Ground System CDR is also planned for FY 1994.

BASIS OF FY 1995 ESTIMATE

In FY 1995, all remaining CDRs for the spacecraft subsystems will be completed. These include the Radio Frequency Instrument Subsystem (RFS) and the High Gain Antenna/Low Gain Antenna (HGA/LGA) subsystem. Spacecraft integration will continue through the first half of FY 1995, followed by the initiation of environmental testing. These include static loads, vibration, acoustic and pyro shock testing which will simulate spacecraft performance during cruise and the prime mission.

Integration and test of the science instruments for both the Orbiter and Probe will continue in FY 1995. Delivery of the Probe instrument flight units is scheduled for mid-FY 1995 -- well ahead of the deliveries of the Orbiter instruments in FY 1996. This is required to allow ESA sufficient time to conduct their own system level testing of the Huygens Probe prior to final delivery in FY 1997.

An Assembly, Test and Launch Operations (ATLO) Plan Review is also planned for FY 1995 to validate detailed planning for system level integration and test activities, including final test and checkout activities at the Kennedy Space Center (KSC) prior to launch. Ground System hardware deliveries will continue in conjunction with the development and test of flight software for the launch and cruise phase of the prime mission. Additional software design and testing in support of the prime mission will continue well beyond launch.

BASIS OF FY 1995 FUNDING REQUIREMENT

DISCOVERY DEVELOPMENT

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Mars environmental survey pathfinder............	--	60,800	77,500
Near Earth asteroid rendezvous..................	--	66,600	52,200
Total....................................	--	127,400	129,700
Launch vehicles................................	--	(24,500)	(51,300)

OBJECTIVES AND STATUS

The Discovery missions are NASA's response to the need for low cost, quick design-to-flight planetary missions. A Discovery mission development cost (phase C/D through launch plus 30 days) must be within $150M (FY 1992 dollars), and the mission must launch within 3 years from start of development. These missions are designed to ensure a continuous stream of new planetary science data and more frequent access to space -- both of which are critical requirements for a robust planetary science program in the future.

The Mars Environmental Survey (MESUR) Pathfinder mission was requested as a new start in FY 1994 and is being conducted as an in-house effort at the Jet Propulsion Laborataory (JPL). The mission is designed to demonstrate the cruise, entry, descent, and landing system approach that will be applied to future missions to safely place a network of small science landers on the Martian surface. Pathfinder will carry three science instruments and a microrover which will be provided by the Office of Advanced Concepts and Technology (OACT). The multispectral stereo Imager for MESUR Pathfinder (IMP) will characterize the Martian surface morphology and geology at a 1-meter resolution. An Alpha-Proton X-ray Spectrometer (APX) will obtain information on the elemental composition of Martian rocks and soil. This instrument will be carried aboard the OACT-developed microrover. An Atmospheric structure Instrument and Meteorology package (AIM) will obtain information on the structure of the Martian atmosphere from measurements during entry and descent, and will obtain <u>in-situ</u> meteorology information while deployed on the Martian surface. The lander will also deploy and operate the OACT-developed microrover flight experiment to evaluate the effects of the Martian surface conditions on the rover design and its ability to deploy and operate science instruments. Portions of the science instruments are being provided by Germany and Denmark. Launch is scheduled for December 1996 aboard a Delta II launch vehicle. Communications will be via the Deep Space Network and mission operations will be supported by the Multimission Operations Systems Office (MOSO) at the JPL.

Detailed design activities are currently underway at JPL in support of a planned Critical Design Review (CDR) in July 1994. Hardware fabrication and assembly will begin by mid-1994 and continue through mid-1995.

Funding is also provided in the FY 1994 budget to initiate development of the NEAR mission. This program is being conducted as an in-house development at the Applied Physics Laboratory (APL). Tracking and navigation support will be provided by the JPL. This spacecraft will conduct a comprehensive study of the near Earth asteroid 433 EROS, including its physical and geological properties and its chemical and mineralogical composition. The spacecraft carries four scientific instruments. The Visible Imager (VI) will provide global imaging coverage as well as detailed views of the asteroid at resolutions as high as one to two meters to reveal details of the geologic processes that have affected its evolution; the Gamma Ray/X-Ray Spectrometer (GXRS) will provide a chemical analysis by measuring several dozen key elements; the Infrared Spectrometer (IRS) will determine the mineral composition of the asteroid's surface; and the Magnetometer, together with radio science, will help characterize its internal structure. Launch will be on a Delta II launch vehicle in February 1996. The spacecraft will flyby the main belt asteroid Iliya in August 1996 en route to rendezvous with 433 EROS in December 1998.

The EROS launch opportunity requires an accelerated launch schedule for NEAR of only 29 months. In FY 1994, the Preliminary Design Review (PDR) and Critical Design Review (CDR) will be completed, and detailed instrument and spacecraft design activities will continue through the beginning of FY 1995.

<u>BASIS OF FY 1995 ESTIMATE</u>

For MESUR Pathfinder, final fabrication and assembly of spacecraft and instrument subsystems will continue through June 1995. All hardware deliveries are scheduled for final delivery by mid-1995 in order to initiate system level integration and testing at JPL. Ground system developments such as flight software and mission sequences will also be supported in FY 1995.

The FY 1995 funding for NEAR supports the completion of detailed design activities following the CDR in late FY 1994. Fabrication of spacecraft and instrument subsystems will be initiated in October 1994 and will continue through June or July. Subsystem level testing will be conducted in parallel, beginning in March 1995. Flight hardware deliveries and system level integration are scheduled for completion by July/August 1995. Spacecraft system level testing will begin in August/September 1995 and continue into FY 1996.

BASIS OF FY 1995 FUNDING REQUIREMENT

MARS SURVEYOR PROGRAM

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Mars orbiter	--	(10,300)*	77,000
Future missions	--	--	1,400
Total	--	(10,300)	78,400
Launch vehicle	--	(7,300)	(21,800)

* Currently funded in Planetary Mission Operations and Data Analysis (MO&DA).

OBJECTIVES AND STATUS

Mars has been a primary program focus due to its potential for previous biological activity and for comparative studies with Earth. The Mars Observer mission was launched in September 1992 and arrived at Mars in August 1993. Unfortunately, communications with the spacecraft were lost just prior to orbit insertion. NASA is currently reassessing its Mars Exploration strategy with the proposed Mars Surveyor program. This is a series of small missions designed to resume the detailed exploration of Mars.

The program will begin in FY 1994 with the development of a Mars Orbiter which will obtain much of the data that would have been obtained from the Mars Observer mission. The orbiter will fly a small science payload, comprised of spare Mars Observer instruments or other candidates, aboard a small, industry-developed spacecraft. Launch is planned for October 1996 aboard a Delta II launch vehicle. This mission is to be succeeded by a series of small communications orbiters and landers which will make in-situ measurements of the Martian climate and soil composition. The first of these missions are scheduled for launch in December 1998. Technology developed by the MESUR Pathfinder mission will be optimized to reduce mission costs and technical risk. Design concepts for these missions are currently being worked in conjunction with the International Mars Exploration Working Group (IMEWG). Current planning assumes two launches in December 1998 and two launches in February 2001. All four of these launches will use a new class of launch vehicle, the Med-Lite, which is smaller than a Delta II but larger than a Pegasus.

Per Congressional direction in FY 1994, \$10.3 million of Mars Observer Mission Operations and Data Analysis (MO&DA) funds will be used to initiate development activities on the new Mars Orbiter mission. The FY 1994 funds will be used to initiate long-lead procurements and proceed with detailed design activities in support of the October 1994 launch.

BASIS OF FY 1995 ESTIMATE

Detailed mission design activities are underway and will continue throughout FY 1994. The FY 1995 funding will support initial instrument and spacecraft subsystem level fabrication and assembly. System level integration and test activities may also be initiated, depending upon schedule progress. Ground System hardware procurements and flight software developments will continue throughout FY 1995 in support of the October 1996 launch. Provided in FY 1995 is $1.4 million to study design concepts for follow-on communications orbiters and small lander missions. Current planning assumes two launches in December 1998 and two launches in February 2001.

BASIS OF FY 1995 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Galileo operations	59,429	59,900	70,700
Magellan operations	7,000	11,800	--
Mars observer operations	40,526	10,300*	--
Voyager-Neptune data analysis	5,010	4,300	--
Planetary flight support	51,500	55,400	57,000
Total	163,465	141,700	127,700

* Funds to be transferred to Mars Surveyor program

OBJECTIVES AND STATUS

The objectives of the Planetary Mission Operations and Data Analysis (MO&DA) program are in-flight operation of planetary spacecraft as well as the acquisition and analysis of data from these missions. The planetary flight support activities are those associated with the design and development of planetary ground operation systems for multiple missions, and other activities that support the mission control, tracking, telemetry, and command functions through the Deep Space Network (DSN) for all planetary spacecraft.

Operations for Galileo began in October 1989 for the spacecraft's six-year journey to Jupiter. The spacecraft passed by Earth last December for the second and last time as it departed the inner solar system. Since launch, the spacecraft has returned the first detailed images ever obtained of an asteroid -- Gaspra. Galileo encountered a second asteroid, Ida, in August 1993. Failure to deploy the High Gain Antenna (HGA) has required a rebaselining of the mission for use of the Low Gain Antenna (LGA) only. Development has begun on the changes in mission design and DSN coverage required to support the new mission requirements. Galileo will release the atmospheric Probe in July 1995 and initiate the Jovian tour the following December.

The Magellan spacecraft was launched in May 1989. Since its arrival at Venus in August 1990, the spacecraft's radar has mapped approximately 99% of the planet's surface to a ground resolution of about 150 meters. The spacecraft successfully completed an aerobraking experiment to circularize the orbit in the summer of 1993. Magellan is currently collecting high resolution gravity data from this new orbit which, when studied in coordination with radar mapping data, will help determine the internal geological processes

responsible for much of the planet's topography. Extensive data processing and analysis of existing radar data sets are underway as well. Mission operations are planned for termination by the end of FY 1994.

The Voyager-2 flyby of Neptune in August 1989 provided our first detailed images of this distant planet as well as previously unknown moons and geyser-like surface eruptions on Triton. Support for analysis of this data has continued since FY 1990. However, due to budget constraints in FY 1995, this program is unfunded beyond FY 1994.

Mars Observer mission operations began in October 1992 after the spacecraft was launched aboard a Titan III with a Transfer Orbit Stage (TOS) upper stage. Communications with the spacecraft were lost in August 1993, just prior to the Mars orbit insertion. Attempts to recover the mission were not successful. NASA is currently developing a new mission to recover as much of the orbiter science as possible. Per Congressional direction, $10.3 million of FY 1994 Mars Observer MO&DA funds have been retained to support a Mars Orbiter mission. This mission is part of the new Mars Surveyor program beginning in FY 1994. Transfer of the residual Mars Observer MO&DA funds will be addressed in a future FY 1994 operating plan.

The Planetary Flight Support line maintains the Mission Operations Support Office (MOSO) at JPL. This program provides ground system hardware, software development and mission support for all planetary programs. At present, MOSO supports ongoing mission operations for Galileo and Magellan as well as final mission close-out activities for the Mars Observer mission. The program also supports the development of generic ground system upgrades such as the Advanced Multimission Operations System (AMMOS). This new capability is designed to improve our ability to monitor spacecraft systems, thereby reducing workforce levels and increasing operations efficiencies for Cassini and other future planetary missions. New missions such as the MESUR Pathfinder and Mars Surveyor program will work closely with the Planetary Flight Support Office to enable the most efficient use of existing ground system capabilities to minimize ground systems requirements and reduce overall mission operations costs.

BASIS OF FY 1995 ESTIMATE

Mission operations, ground system and flight software development activities continue on Galileo, preparing for the July 1995 release of the probe, and the arrival at Jupiter in December. Planetary Flight Support funding supports the development of ground system capabilities required for Galileo prime mission operations. Additional ground system development will continue in preparation for the Cassini launch in October 1997. Development of the AMMOS ground system upgrade will also continue with further software development and testing activities leading to operational capability in time for Cassini and subsequent planetary missions. Work will also proceed with the Pathfinder development team to ensure support for the December 1996 launch.

Due to agency funding constraints, support for Magellan MO&DA and Voyager-Neptune data analysis are unfunded in FY 1995. Repeated attempts to contact the Mars Observer spacecraft in FY 1994 have been unsuccessful. Therefore, consistent with Congressional direction, all support for the Mars Observer mission is discontinued beyond FY 1994.

BASIS OF FY 1995 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Supporting research and technology	71,247	89,800	88,800
Advanced technology development	30,433	25,300	26,300
Total	101,680	115,100	115,100

OBJECTIVES AND STATUS

The Research and Analysis (R&A) program consists of three elements: (1) to assure that data from flight missions is fully exploited; (2) to undertake complementary laboratory and theoretical efforts; and (3) to define technical requirements and develop technologies for future planetary missions.

Supporting Research and Technology (SR&T) funds support basic and applied research across a wide variety of planetary science disciplines. These include Planetary astronomy, planetary geology/geophysics, planetary materials/geochemistry, planetary atmospheres, exobiology and interdisciplinary studies. Planetary astronomy supports observations from ground-based telescopes of solar system bodies, with emphasis on outer planets, comets, and asteroids. Funding also supports continued operation of the Infrared Telescope Facility (IRTF) at Mauna Kea, Hawaii. Planetary atmospheric research studies the properties of other planetary atmospheres (e.g. Venus, Jupiter, Saturn, Uranus, Neptune) which can aid us in better understanding our own weather and climate. Planetary geology/geophysics studies surface processes, structure, and history of solar system bodies. Planetary materials/geochemistry studies the chemistry, composition, age, and physical properties of solid material in the solar system through the study of returned lunar samples, meteorites, and extraterrestrial dust grains. This program is coordinated with the lunar sample and meteorite research, which is supported by other agencies, such as the National Science Foundation (NSF). The operation of the Lunar Curatorial Facility is also supported by this activity. Exobiology supports the development of theoretical models from analysis of existing data and laboratory investigations to increase our understanding of early chemical and biological events that support the origin and evolution of life on Earth and elsewhere in the universe.

Interdisciplinary studies such as the Origins of the Solar System program examine the interrelationships between all types of planetary science data. These studies are correlated with data outside the planetary data base to develop and test new theories regarding the origin and evolution of our solar system. Advanced techniques and technologies for light collection, adaptive optics and light detection are supported to

detect planets around other stars using the twin 10-meter telescopes of the Keck Observatory at Mauna Kea, Hawaii. Ongoing development of the Planetary Data System (PDS) which archives all mission data products in a manner promoting and facilitating their use by the scientific community is also supported.

Advanced Technology Development (ATD) supports the definition of future planetary missions to ensure technical and scientific viability as well as consistency with the overall strategic planning and scientific objectives of the Planetary Exploration program. Funds are also provided for early definition of new science instruments to reduce the cost, mass and volume as well as to provide enhanced capabilities of future science payloads.

Technology developed as part of the Search for Extraterrestrial Intelligence (SETI) program was funded within the R&A budget as the High Resolution Microwave Survey (HRMS). Per Congressional direction, this program was terminated at the beginning of FY 1994.

BASIS OF FY 1995 ESTIMATE

The FY 1995 budget provides ongoing support for advanced technologies in support of future planetary missions. Program activities will focus on the definition of new Discovery mission candidates, the Mars Surveyor program, a Pluto Fast Flyby mission and U.S. support to the European Space Agency (ESA's) Rosetta mission.

Funding is also provided in FY 1995 to support ongoing basic and applied research in the areas of Planetary astronomy, planetary geology/geophysics, planetary materials/geochemistry, planetary atmospheres, exobiology and interdisciplinary studies. Special support in FY 1995 will be provided for science investigations of Galileo data acquired from the asteroids Gaspra (October 1991) and Ida (August 1993). Ongoing support is also provided for the Planetary Data Subsystem (PDS) to archive and disseminate data sets to the science community.

NASA's partnership in the Keck Observatory will continue. Keck I is beginning operations, and the construction of Keck II is underway. The FY 1995 funds will support observing time aboard the Keck I telescope. Operation of the Infrared Telescope Facility (IRTF) and the Lunar Curatorial Facility will also continue.

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1995 ESTIMATES

BUDGET SUMMARY

OFFICE OF LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995	Page Number
Life sciences				
Research and analysis	52,900	55,100	51,900	SAT 2-6
Flight program	81,100	133,100	93,700	SAT 2-10
Centrifuge facility	5,500	--	--	
Subtotal	139,500	188,200	145,600	
Microgravity science research				
Research and analysis	17,900	18,400	21,700	SAT 2-12
Flight program	156,000	158,200	107,200	SAT 2-15
Subtotal	173,900	176,600	128,900	
Shuttle/spacelab payload mission management and integration	94,100	111,500	112,400	SAT 2-17
Space station payload facilities				
Life science facilities	(5,500)	26,000	52,000	SAT 2-19
Microgravity facilities	--	13,000	32,000	SAT 2-19
Subtotal	(5,500)	39,000	84,000	
Total	407,500	515,300	470,900	

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1995 ESTIMATES

BUDGET SUMMARY

OFFICE OF LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Distribution of Program Amount by Installation			
Johnson Space Center	89,600	119,800	115,000
Kennedy Space Center	19,400	22,400	19,000
Marshall Space Flight Center	93,200	113,400	110,700
Langley Research Center	3,600	3,300	2,700
Lewis Research Center	67,300	76,600	69,800
Ames Research Center	49,600	67,600	83,000
Goddard Space Flight Center	300	500	200
Jet Propulsion Laboratory	33,700	20,600	8,500
Headquarters	50,800	91,100	62,000
Total	407,500	515,300	470,900

OBJECTIVES AND JUSTIFICATION

The goals of the Life and Microgravity Sciences and Applications program are to support the primacy of the U.S. as a spacefaring nation and develop enabling technologies. The program directs its effort toward utilizing the unique environment of space to conduct research in the areas of biology, biomedicine, biotechnology, combustion, fluid physics, material science and other phenomena which require a low gravity environment. This research will lead to advances in fundamental scientific knowledge, enabling research technologies and terrestrial and non-Earth applications.

The Life and Biomedical Sciences and Applications program conducts basic and applied biomedical and biological research in order to understand the role of gravity on life processes. The program also defines, develops, and validates enabling technologies for human space flight life support systems. Results from the research and technology development program are applied to maintaining astronaut health and productivity; understanding the response of living systems to weightlessness; studying basic cellular, developmental and physiological processes; and developing environmental health requirements and support systems for long-term piloted space flight. In FY 1994, the Life Sciences program is continuing its cooperation with the National Institutes of Health (NIH), with the objective of increasing participation of the mainstream biomedical community in the program. The NIH Initiative activities include a wide range of ground-based and space flight research opportunities which span both the flight and the research and analysis programs.

The Life Sciences Research and Analysis program supports ground-based research and definition studies in seven major areas: (1) Space Physiology and Countermeasures, (2) Space Human Factors Engineering, (3) Environmental Health, (4) Space Radiation Health, (5) Advanced Life Support, (6) Space Biology, and (7) Global Disease Monitoring. The Research and Analysis program also includes additional projects such as data archiving; NASA Specialized Centers of Research and Training (NSCORTs); NIH Initiative activities; and technology development.

The Life Sciences Flight program, consisting of the Shuttle/Spacelab flight experiments program, the NASA/Mir program and the international Space Station Utilization program, selects, defines, develops, and conducts in-space biomedical and biological research. The flight experiments program is currently analyzing the data returned on the very successful Spacelab Life Sciences mission (SLS-2) and is actively preparing experiments for launch on the International Microgravity Laboratory mission (IML-2), currently planned for

July 1994, which will carry four life sciences investigations. Six payloads are also planned to fly within the Shuttle middeck. As part of Shuttle/Spacelab experiments, the Extended Duration Orbiter Medical Program (EDOMP) is continuing its work to develop specific medical countermeasures for the extension of Shuttle flights to sixteen days. The flight program involves important collaborative activities with other U.S. agencies, including the NIH and the National Science Foundation (NSF), and with the European Space Agency (ESA) and the space agencies of France, Germany, and Japan. Definition and development activities are underway to build payloads for a joint program with Russia that focuses on understanding biomedical problems associated with long-duration missions. In FY 1995, there will be an increase in the level of activities in preparation for utilization of the Space Station. These efforts will include instrument development, principal investigator support and data analysis.

The goal of the Microgravity Science and Applications Research program is to better understand important physical, chemical, and biological processes that are normally made obscure by the effects of gravity. This understanding will add significantly to our knowledge of important industrial processes and may serve as the basis for developing new technologies for use on Earth and in space. In FY 1994 a major collaborative effort with NIH has been initiated in the area of microgravity biotechnology research.

The Microgravity Research and Analysis program supports ground-based research and definition studies for flight experiment candidates in four primary areas: (1) Biotechnology, (2) Combustion Science, (3) Fluid Physics, and (4) Materials Science. The goals of the program are focused on enhancing the capability or quality of microgravity experimental hardware and overcoming existing technology-based limitations. Ground-based research includes laboratories, drop-tubes, drop towers, aircraft and suborbital flight, using sounding rockets.

The Microgravity Research Flight program provides a range of experimental capabilities. The flight experiments program currently supports a wide variety of hardware development, such as unique flight experiments necessary to conduct benchmark research and modular, multi-user research facilities which will be the cornerstone of microgravity science and applications research in the future. Experiments will be principally flown on the Shuttle and Spacelab. Definition and development activities in support of the NASA/Mir Phase 1 program are ongoing in FY 1994 and will continue in FY 1995. Space Station utilization developmental work will continue in the areas of Space Station furnaces, space acceleration monitoring, operations centers, and middeck payload apparatus. The research program also encompasses selected studies in gravitational physics, condensed matter physics, critical point phenomena, and an advanced technology development program.

The Shuttle/Spacelab Payload Mission Management and Integration program performs the mission planning, integration and execution of all NASA/Spacelab, NASA/Mir and attached Shuttle payloads. The program includes integration of the scientific payloads into the various carriers, payload specialist training and system management and engineering development of flight support equipment and software.

The Aerospace Medicine and Occupational Health program is responsible for protecting and promoting the health, safety and productivity of our astronauts in space and the health and safety of all NASA employees. Its goals are to oversee implementation of policies, standards and requirements governing all medical operations within NASA; to develop and recommend requirements for aerospace medicine and operational medical research to support human spaceflight; and to stimulate the application of space-based technology to health. The program has been reorganized to include specific medical applications activities. Occupational Health is supported with Headquarters and Center institutional funding and is budgeted within the new Mission Support appropriation (Research Operations Support).

The telemedicine project will be augmented during FY 1995. The NASA Authorization Act of 1993 (Public Law 102-588) directed the Administrator of NASA, with the Director of the Federal Emergency Management Agency, the Director of the Foreign Disaster, and the Surgeon General of the United States, to "jointly create and maintain an international telemedicine satellite consultation capability to support emergency medical services in disaster-stricken areas." The project's objective is to facilitate the development of national and international telemedicine and biomedical telescience infrastructures to enhance disaster response and improve health care delivery to rural and underserved areas.

A major program emphasis in the life and microgravity science disciplines will be the development of the cooperative research program with Russia. This program will provide NASA with an unique opportunity to conduct on-orbit, long-duration research including life and microgravity sciences and to conduct technology and systems validation for the development and operation of the international Space Station. In addition to the current 1995 Shuttle/Mir flight, new activities will incorporate up to nine additional Shuttle flights to Mir, up to 24 months of total U.S. crew stay time on Mir and an expanded accommodation of U.S. experiments on Mir, through the use of the Russian Spectr and Priroda modules.

The program will be responsible for the design and development of the Space Station Payload Facilities in FY 1995. These payloads will provide researchers with facilities for gravitational biology, human research, biotechnology, combustion and fluids as well as a Habitat Holding System/Centrifuge and a Space Station Furnace Facility.

A key program objective is that all research must be peer-reviewed. This policy is being implemented by all elements of the program by utilizing extramural experts to evaluate the technical merit of research proposals. In some cases involving joint projects with the NIH and the NSF, peer review is done by our partner agency.

BASIS OF FY 1995 FUNDING REQUIREMENT

LIFE SCIENCES RESEARCH AND ANALYSIS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Life sciences research and analysis.............	52,900	52,400	43,900
Aerospace medicine and occupational health......	--	2,700	8,000
Total....................................	52,900	55,100	51,900

OBJECTIVES AND STATUS

The Life Sciences Research and Analysis program goals are to advance knowledge in all relevant areas of biomedicine and biology and develop technologies and medical and biological systems which enable safe human habitation in space. The objectives of the Life Sciences Research and Analysis program are to support basic and applied studies which prepare for flight investigations on the Shuttle, the U.S./Russian cooperative research program, and the Space Station; to perform analysis of data from previous space flights; and to develop procedures and techniques in support of human space flight, such as environmental standards and monitoring equipment. Life sciences research and analysis is composed of seven program elements: (1) Space Physiology and Countermeasures; (2) Space Human Factors Engineering; (3) Environmental Health; (4) Space Radiation-Health; (5) Advanced Life Support; (6) Space Biology; and (7) Global Disease Monitoring. Life Sciences Research and Analysis also includes the following additional projects and activities: data archiving; NASA Specialized Centers of Research and Training (NSCORTs); advanced technology development; and National Institutes of Health (NIH) initiatives.

All research sponsored by the Life and Biomedical Sciences and Applications Division will be peer-reviewed in FY 1994 and FY 1995. For the vast majority of the program, these reviews are being conducted for both the intramural and extramural research program by the American Institute of Biological Sciences. For the remainder of the program, peer reviews will be done under cooperative agreements with the NIH or the National Science Foundation. For all peer reviews, care is taken to assure that the standards are uniform, that qualified individuals are chosen to evaluate the proposals, and that the reviewers are not associated with the projects under consideration.

The space physiology and countermeasures program focuses on understanding the mechanisms and preventing the consequences of acute and chronic physiological and psychological problems associated with human space flights of extended duration. The space human factors engineering program conducts research and technology development to improve the interaction of people with machines and environments, in space and on the ground.

in support of space operations. The objectives of the environmental health program are to assess spacecraft environmental risks to determine spacecraft maximum allowable concentration limits of environmental components, and to develop new technologies for environmental monitoring. The space radiation-health program is working to establish the scientific basis for radiation protection of humans engaged in space flights. The advanced life support program effort is focused on the development of systems that will provide air, water, and food to support life through combined physical-chemical-bioregenerative processes which would require no inputs from the external environment except energy. Other advanced extravehicular activity technologies are in development to ensure the safety and productivity of future crews. The space biology program explores the role of gravity in life processes and uses gravity variations as an environmental tool to investigate fundamental biological questions. The global disease monitoring program uses the technology of remote sensing to predict ecological changes and disease transmission patterns.

Data archiving efforts will develop an operational database for archiving results of the NASA life sciences research program that will be accessible to the life sciences community nationwide.

The objectives of the advanced technology development program are to identify and develop technologies that will significantly improve the science return capability of life sciences flight hardware and, wherever possible, to ensure that these technologies find commercial sector applications.

Cooperation with NIH has led to the development of new NASA Specialized Centers of Research and Training (NSCORTs), e.g., with the National Institute on Deafness and Other Communication Disorders. The NSCORT program serves to advance basic knowledge, to generate effective strategies for solving problems in focused research areas, and to train young scientists.

Other NIH initiatives have led to funding of individual investigators, the development of a new program of NASA supplements to ongoing NIH grants, a series of conferences and workshops to inform the biomedical research community about research opportunities, and joint activities with the National Library of Medicine concerning bibliographic databases and flight data archiving.

The Aerospace Medicine and Occupational Health (AMOH) program is responsible for the Agencywide program that ensures the health and medical aspects of the safety of astronauts and promotes and protects the health and safety of all NASA employees. The major medical support function of AMOH includes oversight of operational medical programs for human space flight and Agency aircraft operations, including astronaut selection, medical certification, medical monitoring, and medical care for astronauts and their families; development and recommendation of requirements for medical care systems for human space flight and operational medical research; control and minimization or elimination of exposure to toxic exposures and other health hazards; health promotion and preventive health care programs; and oversight of compliance with health and health related laws and regulations. The program is also responsible for demonstrating and promoting the applications of space-based technologies to health care, including development and maintenance of a

Congressionally-mandated international telemedicine program to support emergency medical services to disaster stricken areas (NASA Authorization Act of 1993 [Public Law 102-588]). The objective of this telemedicine project is to facilitate the development of national and international telemedicine and biomedical telescience infrastructures to enhance disaster response and improve health care delivery to rural and underserved areas.

BASIS OF FY 1995 ESTIMATE

The program's basic research during FY 1995 will continue to use Earth-based models to simulate the effects of weightlessness and other components of the space flight environment, and will provide for extended data analysis and supporting studies so that investigators can learn as much as possible from data collected in space. These studies will further refine our understanding of how microgravity can be used to investigate questions of medical and basic biological importance on Earth such as blood pressure control, maintenance of bone and muscle mass, vestibular function and the regulation of balance, and cell metabolism and division. The reduction from FY 1994 funding levels is due to the transfer of the Small Business Innovation Research (SBIR) funds from the program to a central Agency account.

The environmental health program will develop and refine environmental standards in areas such as microbiology and toxicology; these standards will be key to developing safe and cost-effective life support and environmental monitoring systems. The radiation health program will continue to provide for monitoring of radiation exposure on Shuttle crews, refine dose estimates and study the biological effects (especially the increased risk of cancer) of space radiation exposure. In order to address NASA's operational needs, the space human factors engineering program will test and develop new training procedures, design new systems that use state-of-the-art knowledge of human operations with complex automated systems, and use remote, harsh, and isolated environments such as the polar regions to conduct analog studies.

The advanced life support program will develop regenerative technologies which will reduce operations and life cycle costs, increase mission productivity, maintain mission safety, stimulate the economy, and facilitate environmental management. During FY 1995 the advanced life support program will continue the development and demonstration of advanced water processing systems, sensor technologies, thermal control concepts, and air revitalization technologies.

The global monitoring and disease prediction program will use data from both remote sensing and field measurements to drive models of mosquito population dynamics and disease transmission. The results will be used to predict malaria risk at specific sites and times and to facilitate mosquito control methods. During FY 1995 NASA anticipates that it will work more closely with NIH and the World Health Organization to evaluate and apply the results of work in this program area.

NASA will continue to work with the National Library of Medicine to establish "Spaceline," an on-line bibliographic database in the space life sciences. Supported by FY 1995 resources, "Spaceline" will first be accessible to the scientific community beginning in FY 1995. Life sciences research and analysis resources will support the establishment of additional databases designed to make flight experiments and other research findings more widely available to the general scientific community.

FY 1995 resources will support the establishment of the eighth and ninth NSCORTs. Candidate proposals will be submitted, reviewed, and executive recommendations will be made by the Office of Life and Biomedical Sciences and Applications Subcommittee. Disciplines will be selected for the new NSCORTs before the end of FY 1994. During FY 1995 the life sciences NSCORTs will conduct research and training in the following science programs: Space Biology, Environmental Health, Space Radiation Health, Controlled Ecological Life Support Systems, Integrated Physiology, Plant Biology and Physiology, and Vestibular Research. Research training funded by the Center for Vestibular Research, the first joint funded NSCORT, will result in a 20% increase in trainees in vestibular physiology, relative to the number which existed in the U.S. prior to the establishment of the center.

The advanced technology development program will sponsor technology development activities that enhance the capability, reliability or quality of life sciences flight hardware, provide breakthroughs to technical problems that currently limit science return from existing flight equipment, enable new types of scientific investigations not previously possible, promote technology transfer of life sciences technologies to industry, establish partnerships with industry, universities and other agencies to facilitate technology development and transfer. Each advanced technology development project will be responsible for identifying technology end-users.

With the reorganization of the NASA Occupational Health function into the Aerospace Medicine and Occupational Health, the program is responsible for medical support of astronauts and pilots, including oversight of all operational medical program supporting human space flight. This includes oversight of medical activities funded under the new institutional Mission Support (Research Operations Support) appropriation (approximately $27.0 million per year), and is augmented by this FY 1995 request. The AMOH program will be directly responsible for Clinical Medicine activities including telemedicine. During FY 1994, AMOH is consolidating oversight of these funds within the Agency to better coordinate medical support of critical operational programs. In addition, the AMOH is developing operational medicine requirements during a time of rapidly expanding requirements issues -- operational medical requirements for Space Station, medical support (including telemedicine support) for our astronaut crews training in Russia, international telemedicine infrastructure requirements (links to Moscow, Kazakhstan, etc.), and telemedicine infrastructure requirements to support human space flight (links from Johnson Space Center to Space Shuttle, Mir, Star City in Moscow, U.S. academic medical centers for consultation, etc.).

BASIS OF FY 1995 FUNDING REQUIREMENT

LIFE SCIENCES FLIGHT PROGRAM

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Flight experiments program	73,500	99,300	70,000
NASA/Mir program	7,600	33,800	18,700
Space station utilization program	--	--	5,000
Centrifuge	5,500	--	--
Total	86,600	133,100	93,700

OBJECTIVES AND STATUS

The primary objective of the Life Sciences Flight program is to bring to maturity those investigations dealing with living systems which require access to space in order to discern and understand behavior, response, and basic mechanisms in organisms during their adaptation to space. The program includes selection, definition, science and hardware development, in-flight operation, data analysis, and reporting on medical, biological and technical evaluation investigations involving humans, animals, and plants. Selected flight experiments lead to a better understanding of gravitational adaptation and enhance our understanding of specific phenomena controlling function, modification, and repair of living systems on Earth. The Life Sciences Flight program includes the following activities:

- the ongoing NASA Shuttle and Spacelab flight experiment programs;
- the cooperative research program with the Republic of Russia, including the cooperative research series aboard the Mir; and,
- the science utilization/experiments program planned for the U.S./Russian/international Space Station.

The FY 1994 began successfully with the flight of the life science-dedicated Spacelab, SLS-2. This mission set standards for science operation as well as a record time aloft for the orbiter. During the remainder of FY 1994 fourteen primary investigators whose research focus is in the cardiopulmonary, metabolic, neurovestibular and musculoskeletal disciplines, along with 33 investigators in the tissue sharing program will complete their analyses of the data returned from the 475 subject runs and 11,750 animal tissues. They will publish their results during FY 1995. The International Microgravity Lab mission, IML-2, with four NASA-sponsored life science investigations, is also being prepared for a July 1994 flight.

Also during FY 1994 the program plans to fly six payloads within the Shuttle middeck as part of the life sciences small payload program that uses human, animal, plant, and cellular subjects. Several of these missions are scheduled with the cooperation and participation of the National Institutes of Health (NIH).

Life sciences flight experiments received 161 proposals in response to a joint Announcement of Opportunity (AO) with NIH. The AO was in support of the Neurolab Spacelab mission, SLS-4, which is now manifested for flight in 1997. The SLS-3 mission has been canceled because of Agency budget constraints and the earlier planned availability of Space Station payload opportunities. The program plans to re-manifest some of the science payloads and experiments on other carriers to the greatest extent possible.

Life sciences flight experiments collaborative research with Russia will accelerate during the next several years. A number of payloads are being developed for placement on the Mir during FY 1995, at which time a NASA astronaut will begin a 90-day stay on-orbit. In support of the follow-on space research that the Administration anticipates with Russia, the flight experiments program this year will further define its program to take advantage of up to four long-duration U.S. crew stays on Mir and up to ten Shuttle visits. The program will sponsor investigations in the areas of environmental health, life support technology, biomedical, basic biological sciences, radiation health, and global monitoring. Finally, during FY 1994, the program will complete negotiations and obtain the necessary approvals to acquire a half-interest in a Russian Bion spacecraft.

BASIS OF FY 1995 ESTIMATE

During FY 1995, the life sciences flight experiments program will build efforts initiated during FY 1994 to construct a well-integrated, efficient, economical response to emerging flight opportunities and developments. The program expects that emerging opportunities on Shuttle and Spacelab, through the U.S./Russian cooperation research program, and through the U.S./Russian/international Space Station will provide complementary flight opportunities which in turn will advance the life sciences program's research objectives. The decrease in FY 1995 from the previous year is primarily the result of a reduction in the Spacelab program activity and other reductions taken for program efficiencies and indirect contractor reductions. Mir program funding was also substantially less in FY 1995 after reaching a peak in FY 1994. Space Station work will substantially increase in FY 1995-FY 1996.

The majority of SLS-3 science investigations which are being re-manifested on other carriers will be supported with FY 1995 resources, enabling participating investigators to achieve their most important research aims. For instance, a component of SLS-3 science will be re-manifested to fly on STS-71, thereby taking advantage of the flight opportunities offered by the U.S./Russian cooperation research program.

The life sciences program anticipates that FY 1995 resources will support a more vigorous small payload program that will include enhanced NIH participation. During FY 1995, the program's emphasis will be on

cooperative science investigations with NIH and the Canadian Space Agency. The science investigations will focus on immune cell function in microgravity and on understanding gravity's influence on developmental biology. The equipment used to accomplish these investigations are precursors to similar hardware that will be developed for Space Station. Biomedical investigations will be carried as appropriate on different flights in both FY 1994 and FY 1995, leading to crew certification of the Extended Duration Orbiter (EDO) for sixteen-day flights.

The NASA/NIH cooperative international SLS-4 mission payload complement will be finalized in FY 1995. Research proposals were received in December 1993, peer review will occur in mid-FY 1994, and selection for definition will occur during the summer of FY 1994. The SLS-4 launch is scheduled for late 1997. The SLS-4 mission, also called Neurolab, will be the main NASA contribution to the Congressionally-chartered "Decade of the Brain" and will be devoted to brain and behavioral research. It will be the first joint Spacelab with NIH and the National Science Foundation. Substantial foreign participation on this mission is expected, thereby enabling the U.S. to use hardware previously developed by our foreign partners.

The U.S./Russian cooperation research program will use FY 1995 funds to support the science to be flown on planned Shuttle missions to the Mir-1 Space Station. Final science package outfitting of STS-71, the first Shuttle docking mission to Mir-1, will be completed in early FY 1995 with docking scheduled for May 1995. Funding for the development, integration, and launch of supporting flight hardware in the Russian Spektr, Priroda, and Progress modules will also be completed during FY 1995. The experiment hardware contained in these modules will be used throughout the ten U.S./Russian cooperation program.

The FY 1995 resources will also be used for the acquisition of a fourteen-day Bion-11 Biosatellite mission from the Russians and development of flight hardware. Now scheduled for launch in late 1995 or early 1996, this mission will be a flight of primates to accommodate muscle and bone physiology and other science originally planned for the SLS-3 mission. The U.S. investment in the program will purchase 50% of the payload science and resulting data analysis.

Our collaborative activities with Russia in the Mir and Bion programs will pave the way for the life sciences program's use of the U.S./Russian/international Space Station. Space Station activities for the Life and Microgravity Sciences and Applications program and its science community will include selecting investigations during FY 1995 and development of the related science for implementation on the Space Station beginning in FY 1998. The FY 1995 resources for the flight experiments program will enable twenty new investigations per year for use on the life sciences station facilities.

BASIS OF FY 1995 FUNDING REQUIREMENT

MICROGRAVITY SCIENCE RESEARCH AND ANALYSIS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Microgravity science research and analysis......	17,900	18,400	21,700

OBJECTIVES AND STATUS

The objective of this program is to better understand important physical, chemical, and biological processes that the effects of gravity obscure on Earth. The research and analysis activity provides the scientific foundation for such understanding and serves as the basis for all current and future projects. Ground-based research leads to space-based investigations with potential for future terrestrial and space-based applications. Areas of research emphasis include four primary disciplines: (1) Biotechnology, which focuses on macromolecular crystal growth and mechanical environmental influences on cell science; (2) Combustion Science; (3) Fluid Physics, which studies the behavior of fluids and transport phenomena and condensed matter physics; and (4) Materials Science, which investigates electronic and photonic materials, metals and alloys, glasses and ceramics. The program also supports selected studies in gravitational physics, condensed matter physics and critical phenomena (which is referred to as benchmark sciences). Developing a comprehensive approach of basic and applied research is a major goal of this program.

Microgravity research has demonstrated that gravity influences protein crystal growth and that a reduced gravity (microgravity) environment improves crystal characteristics. Better understanding of these characteristics can lead to improved efficiency in drug design and to new techniques for growing protein crystals on Earth. An important microgravity research instrument, the bioreactor, provides researchers with a powerful tool for probing mechanisms that influence how cells join together to form tissue.

Combusion is a vigorous area of research. Such research has major international significance in electric power generation and transportation energy and has potential to play a major role in the reduction of environmental pollutants. The research has been invigorated by the selection of new peer-reviewed science.

Understanding the behavior of fluids and their effects on materials processes and vapor-liquid mixtures has profound implications for production and control processes on Earth and in future space engineering applications. Materials science experiments continue to be a significant component of the microgravity program with potential applications in industrial production processes. Fundamental physics research can be conducted in microgravity at a level of accuracy not possible on Earth. Advances in technology for science instrument development and for basic applications are emphasized.

These research projects are a result of proposals from the scientific community stemming from NASA research announcements. These projects are extensively reviewed by peer groups prior to selection and funding. This program also provides analytical support and technology development for future ground and space research capabilities. The advanced technology development program encompasses a wide variety of technologies and techniques including crystal growth instrumentation development, real time x-ray microscopy, combustion dynamics and microwave furnace development. This development work will significantly enhance the capability or quality of microgravity experimental hardware.

BASIS OF FY 1995 ESTIMATE

Ground-based research and analysis will continue in FY 1995 in the areas of biotechnology, combustion sciences, fluid physics, materials science, and benchmark science. Research objectives include definition of the role of gravity-driven influences in a variety of processes. Specific areas of research will include tissue culture technology, protein crystal growth phase transitions and critical phenomena, solid-fluid interface dynamics, near-limit flammability and combustion stability and the solidification and crystal growth of metals and alloys. Solicitations (NASA Research Announcements and Announcements of Opportunity) in fluid physics and materials sciences will be released to focus and expand the science community involvement in these areas. This will allow for the development of strong candidates for future flight opportunities.

BASIS OF FY 1995 FUNDING REQUIREMENT

MICROGRAVITY SCIENCE FLIGHT PROGRAM

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Flight experiments program	151,600	149,100	83,200
NASA/Mir program	4,400	5,800	18,400
Space station utilization	--	3,300	5,600
Total	156,000	158,200	107,200

OBJECTIVES AND STATUS

During FY 1993, the second United States Microgravity Laboratory (USML-2), the second United States Microgravity Payload (USMP-2) and the second International Microgravity Laboratory (IML-2) missions were under development.

The Flight Experiments program provides hardware for experiments for a wide range of flight opportunities in the Shuttle middeck, Spacelab, and Shuttle cargo-bay experiments that will achieve the objective of better understanding key physical, chemical and biological processes in the microgravity environment. The program includes selection definition and development, in-flight operational support and data analysis for all Microgravity flight experiments. In FY 1994, the premier Microgravity missions will be the second flight in the International Microgravity Laboratory Spacelab series (IML-2) and the second flight in USMP non-pressurized volume Shuttle series (USMP-2). Flight hardware such as Space Station acceleration measurement systems and furnaces will also be designed and developed in support of the NASA/Mir program. In FY 1994, design of Space Acceleration Measurement System (SAMS-II) for the Space Station will also be initiated. These opportunities allow for conducting microgravity research, consistent with the strategy of evolving microgravity experiments from short to long-duration periods of on-orbit operations.

BASIS OF FY 1995 ESTIMATE

The FY 1995 funds are required to continue experiment payload development for use in the Shuttle middeck, Spacelab, and Shuttle cargo bay for future flights of the USML and USMP series and for the Microgravity Sciences Laboratory (MSL) Spacelab flight scheduled for 1997. Investigations are planned in electronic materials, metals and alloys, glasses and ceramics, biotechnology, combustion, and fluid physics and dynamics. The decrease in FY 1995 from the previous year coincides with a reduction in Spacelab activities and substantial reductions taken for contractor indirect manpower program efficiencies, reduction of

in-house support service contractors, and the transfer of SBIR funds to a central Agency account. Space Station activities will accelerate substantially in FY 1995-FY 1996.

In FY 1995 the development begins of new equipment for the Shuttle middeck and other planned Spacelab missions. This new equipment will be used to carry out scientific investigations chosen from NASA Research Announcements in Combustion Science, Materials Science, Biotechnology, Fluid Physics, and Benchmark Science. These investigations represent the future of the microgravity science program, as the results of USML, IML, and USMP missions series are disseminated, and the program readies investigations for later Shuttle missions. The major microgravity Spacelab mission in FY 1995 will be the USML-2.

Activities will continue in FY 1995 on the first cooperative U.S./Russia Spacelab-Mir mission, scheduled for a 1995 launch. Funding will support up to four additional long module flights with Mir, with the first flight in 1996. Three and one-half double racks are planned for each of these flights for fluids, combustion, and materials sciences experiments. EXPRESS rack utilization is part of this plan. In addition, the Mir is to be utilized for Biotechnology (equivalent of eleven middeck lockers); glovebox experiments (equivalent of seven middeck lockers), and for measuring the acceleration environment (equivalent of 4.5 lockers). Microgravity sciences and applications also plans to use the Russian furnaces for materials research. Additional locker spaces are planned for stowage and resupply of experiments.

Space Station utilization efforts will intensify with substantial work being initiated for integration, training and operations preparation, middeck payload development for biotechnology, fluids and combustion experiments and continued work in developing acceleration measurement systems.

BASIS OF FY 1995 FUNDING REQUIREMENT

SHUTTLE/SPACELAB MISSION MANAGEMENT AND INTEGRATION

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Shuttle/spacelab mission management and integration	94,100	111,500	112,400

OBJECTIVES AND STATUS

The primary objective of the Shuttle/Spacelab Mission Management and Integration program is to provide the mission planning, integration, and successful execution of all NASA Spacelab, NASA/Mir, and attached Shuttle payloads. This includes system management and engineering development of flight support equipment and software; development of certain interface hardware between payloads and platforms; payload specialist training and support; integration of the science payloads with the Spacelab system; payload flight operations; and data dissemination to experimenters.

Mission management activities are ongoing for several NASA Spacelab and attached Shuttle payload missions. Missions scheduled for flight in calendar year 1994 include the second flight of the cooperative International Microgravity Laboratory (IML-2), the second flight of U.S. Microgravity Payloads (USMP-2), the first and second flights of an imaging radar (SLR-1 and 2), and the flight of the Lidar In-space Technology Experiment (Lite-1). Preliminary work for other missions will also be initiated in FY 1994.

Mission management activities also commenced in 1994 in support of the first flight of the Spacelab Mir (SL-M) mission in mid-1995 with preparations for experiment hardware shipments to Russia for installation and launch aboard the Russian modules, Spektr and Priroda. The integrated payload design for SL-M was completed in December 1993, and implementation of this mission for 1995 is in progress. The NASA/Mir program will provide an excellent opportunity to demonstrate technologies which may be applicable to the development and operation of the international Space Station program.

BASIS OF FY 1995 ESTIMATE

Mission management activities will continue in FY 1995 with several Spacelab missions planned this fiscal year [Astronomy Spacelab-2 (ASTRO-2), Atmospheric Laboratory for Applications and Science (ATLAS-3), USML-2, and Spacelab-Mir]. In addition, mission management activities will continue for the ongoing research activities aboard Mir with both U.S. astronauts and cosmonauts, the preparations and launch of the second

mission to Mir, planning and preparations for additional docking missions to Mir in FY 1996 and FY 1997 for crew exchange and logistics resupply. The Agency has implemented initiatives to reduce the overall costs of the Spacelab mission management activities. NASA has established a challenge to reduce mission management support contractors and indirect rates, and to implement management efficiencies and consolidations.

BASIS OF FY 1995 FUNDING REQUIREMENT

SPACE STATION PAYLOAD FACILITIES

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Life sciences facilities	(5,500)	26,000	52,000
Microgravity facilities	--	13,000	32,000
Total	(5,500)	39,000	84,000

OBJECTIVES AND STATUS

Gravity is a universal force that affects every aspect of our life, shaping all physical, chemical and biological processes. Low Earth-orbit offers a unique environment with a near-absolute vacuum, a spectrum of radiation, temperature extremes and reduced gravitational forces. The Space Station, as a permanently space-based laboratory, offers the opportunity to study fundamental processes without the masking influences of Earth's gravity. The Space Station will be an interactive laboratory in space modeled closely after those on the ground. The observations of the crew, their ability to change protocols and enhance the science is critical to the types of experiments planned for life and microgravity sciences. Six facility-class payloads will be developed for the Space Station: (1) Human Research Facility (HRF), (2) Gravitational Biology Facility (GBF), (3) Habitat Holding System (HHS)/Centrifuge, (4) Fluids/Combustion Facility (FCF), (5) Biotechnology Facility (BTF), which includes protein crystal growth experiments, and (6) Space Station Furnace Facility (SSFF). These facilities will be able to accommodate a wide variety of principal investigators across a broad range of scientific disciplines.

The Human Research Facility, Gravitational Biology Facility and the Habitat Holding System/Centrifuge Facility will be managed under the Life and Biomedical Sciences and Applications program. The HRF will provide monitoring of the crew in their adaptation to space so that countermeasures to this adaptation can be developed in order to lessen potential problems on return to Earth. It will also enable the conduct of basic science investigations into the mechanisms leading to these changes. The HRF provides state-of-the-art instruments to study most body systems, (e.g., metabolic, fluid, heart/lungs, nervous system, muscle, bone, etc.). The GBF will allow researchers to monitor and interrogate a number of lesser species (plants, cells, insects, fish, etc.) in order to understand their adaptive processes. The GBF will not only provide the life support for the specimens and standard measurement instruments but also allows for integration of investigator-unique equipment to conduct specialized studies normally performed in the ground-based laboratories. The Habitat Holding System/Centrifuge facility will include zero-g holding facilities for

these species, necessary transport and life support accommodations as well as a rotor that provides both one-G and fractional gravity levels to animals and plants. This facility will represent a marked enhancement of basic research capability for life sciences and has been a top priority recommendation of the National Academy of Sciences for several years.

The Microgravity Sciences and Applications program will manage the development of the Fluids/Combustion Facility, Biotechnology Facility (including Protein Crystal Growth payloads) and the Space Station Furnace Facility (SSFF). The Fluids/Combustion Facility will play a key role in understanding combustion processes and fluid dynamics in the absence of gravitational forces. This work has great potential for Earth applications in a wide variety of fields including energy generation/utilization, transportation, materials processing and power plant operation. This facility will consist of common support systems and combustion and fluids racks for experiment-specific hardware. The Biotechnology Facility will provide researchers with a better understanding of complex protein structures and maintenance and response of mammalian tissue cultures in microgravity. This knowledge can be applied to the production of both space-based and terrestrial pharmaceuticals, medicines and biological substances. The SSFF will consist of three racks, one for diagnostic/controls and two racks devoted to instruments. The work performed in the SSFF has potential application in the materials industries such as electronics and metals/alloys/ceramics development.

The FY 1994 efforts are focused on definition studies and technology development for these payload facilities. Full scale development of the Space Station Furnace Facility was initiated in November 1994. The development contract award (Phase C/D) for the Habitat Holding System/Centrifuge is also planned for FY 1994. Preliminary requirements analysis and design efforts will be performed for the GBF, HRF, BTF, and Protein Crystal Growth Payloads. The SSFF, GBF and portions of the FCF will be performed in-house at the Marshall Space Flight Center, the Ames Research Center, and Lewis Research Center respectively.

BASIS OF FY 1995 ESTIMATE

The FY 1995 requirements for the life sciences and microgravity sciences payload facilities are based on science and technical requirements and the expected on-orbit availability of the Space Station payload capabilities. The initial increments for the GBF and HRF are planned for first deployment in FY 1998 and will be delivered to the station as part of the U.S. laboratory module outfitting flight. The next GBF and HRF facility increments are targeted for FY 2000. The Habitat Holding System and Glovebox of the Centrifuge Facility will be delivered to the Station in 2002. The centrifuge rotor is planned for launch in 2004. Microgravity protein crystal growth payload facilities are planned for FY 1997 launch, the Biotechnology Facility will be deployed in FY 1998, and the Furnace Facility and the Fluids/Combustion Facility are targeted for station delivery in FY 1999.

In FY 1995, detailed configuration design work will begin and selected subsystems manufacture will begin for the GBF and HRF. Detailed design and initial development of the Centrifuge will also accelerate.

Fabrication will begin on the protein crystal growth payloads. The BTF, SSFF, and FCF will be in the design phase in FY 1995. Preliminary Design Reviews (PDR) will be held in FY 1995 for the BTF and portions of the SSFF and Fluids/Combustion Facility.

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 1995 ESTIMATES

BUDGET SUMMARY

OFFICE OF MISSION TO PLANET EARTH

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995	Page Number
Earth observing system	263,747	318,776	455,100	SAT 3-7
Earth observing system data information system	130,688	188,158	284,900	SAT 3-10
Earth probes	99,413	96,426	82,000	SAT 3-13
Space station attached payloads	--	--	9,800	SAT 3-15
Advanced communications technology satellite	3,968	3,000	2,300	SAT 3-16
Payload and instrument development	35,461	22,900	19,500	SAT 3-17
Ocean color data purchase	15,570	3,400	600	SAT 3-20
Consortium for international earth science information network	18,000	5,000	6,000	SAT 3-21
Landsat	25,000	54,100	62,400	SAT 3-22
Mission operations and data analysis	93,983	97,444	97,500	SAT 3-23
Interdisciplinary research	4,453	5,000	4,600	SAT 3-26
Modeling and data analysis	42,571	44,245	41,200	SAT 3-27
Process studies	119,255	129,667	119,400	SAT 3-30
Airborne science and applications	20,707	25,200	26,000	SAT 3-33
Mission to planet earth information systems	11,200	11,184	9,800	SAT 3-35
Subtotal	884,016	1,004,500	1,221,100	

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 1995 ESTIMATES

BUDGET SUMMARY

OFFICE OF MISSION TO PLANET EARTH

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1993	FY 1994	FY 1995	Page Number
	(Thousands of dollars)			
Construction of Facilities				
Earth systems science building	--	12,000	17,000	CF 2-1
Langley research center distributed active archive center	--	8,000	--	
Goddard space flight center distributed active archive center	15,300	--	--	
Consortium for international earth science information networks building	37,000	--	--	
Subtotal	52,300	20,000	17,000	
Total	936,316	1,024,500	1,238,100	
Distribution of Program Amount by Installation				
Johnson Space Center	211	130	130	
Kennedy Space Center	75	100	100	
Marshall Space Flight Center	10,467	29,100	7,100	
Stennis Space Center	711	600	500	
Langley Research Center	24,955	41,600	43,300	
Lewis Research Center	4,063	3,500	1,900	
Ames Research Center	39,518	35,900	34,000	
Goddard Space Flight Center	607,142	605,400	815,000	
Jet Propulsion Laboratory	114,616	167,200	203,400	
Headquarters	134,558	140,970	132,670	
Total	936,316	1,024,500	1,238,100	

OFFICE OF MISSION TO PLANET EARTH

OBJECTIVES AND JUSTIFICATION

The ongoing Mission to Planet Earth (MTPE) program is making critical, near-term contributions to understanding the Earth as an integrated system as well as environmental issues, such as global warming and ozone depletion. NASA's base program combines ground-based measurements, laboratory studies, data analysis and model development with a progressive series of satellite missions studying cloud climatology, Earth radiation budget, ozone levels, atmospheric chemistry, and ocean circulation. The NASA program also supports a broad interdisciplinary, basic research program.

The ability to measure the extent of both the natural and human-induced changes in our global ecosystem is only a preliminary step: the capability to model and predict the consequences of global change is the ultimate objective. The U.S. Global Change Research Program (USGCRP), in which NASA is a major participant, provides a focused and effective mechanism for coordinating and directing federally-funded global change research.

The specific objectives of the NASA Mission to Planet Earth program are to improve our understanding of the processes in the atmosphere, oceans, land surface and interior of the Earth, and to advance our knowledge of the interactions between these components. The program provides space observations of parameters involved in these processes and extends the national capability to predict environmental phenomena, both short and long term, and their interactions with human activities. Because many of these phenomena are global or regional, they can be most effectively, and sometimes only, observed from space. NASA's programs include scientific research efforts as well as the development of new technology for global and synoptic measurements. NASA's research satellite, Shuttle/Spacelab payload, and airborne science and applications programs provide a unique view of the planet Earth, its physical dynamics, radiant energy, chemical, and ecological processes that affect habitability, bio-diversity, and the solar-terrestrial environment.

NASA has established several significant objectives in the Mission to Planet Earth program for the next decade. Missions and research will emphasize advancement of our understanding of the upper atmosphere through the determination of the spatial and temporal distribution of ozone and select nitrogen, hydrogen, and chlorine species in the upper atmosphere and their sources in the lower atmosphere. NASA researchers will continue to investigate the solid Earth system and will characterize the current state of the terrestrial landscape, including the biosphere and hydrosphere.

Investigators already use space-derived measurements to increase understanding of large-scale weather patterns. Researchers will increase capabilities for severe storm forecasting as well as knowledge of ocean productivity, circulation, and air-sea interactions. A long-term strategy for climate observation and prediction is required improve knowledge of seasonal climate variability. Understanding the cycling of key biogeochemical elements and interactions between the biosphere and the climate system is essential to our understanding of the global environment.

The major element of Mission to Planet Earth is the Earth Observing System (EOS), the primary objective of which is to document global climate change and to observe regional-to-global scale processes. Utilizing several satellite series, EOS will document global climate change over a fifteen-year period to provide long-term data sets for use in modeling and understanding global processes. This process and modeling research effort will provide the basis for establishing predictive global change models for policy makers' and scientists' use in formulating strategies to manage human impacts on global processes such as the greenhouse effect, ozone depletion, and deforestation.

The Earth Probes program provides small, specialized satellites, as well as instruments for non-NASA satellites to complement data gathered by EOS. These satellites require special orbits and spacecraft capabilities and will provide data on tropical rainfall (Tropical Rainfall Measurement Mission (TRMM)), ocean wind speed and direction (NASA Scatterometer), and global ozone concentrations (Total Ozone Mapping Spectrometer (TOMS)). These missions are necessary for a more complete understanding of the global climate system.

The Advanced Communications Technology Satellite (ACTS) was launched in September 1993. The program will maintain U.S. leadership in the communications satellite market through the development and flight verification of advanced technologies that enhance the capability of communications satellites. The budget for ACTS remains in the Mission to Planet Earth program, but following completion of on-orbit checkout, ACTS management responsibility will be assumed by of the Office of Advanced Concepts and Technology (OACT).

The objectives of the Payload and Instrument Development program are to develop, test, and evaluate Earth-viewing, remote sensing instruments and systems. Experimenters will obtain data necessary for basic research projects as well as provide correlative and developmental feasibility information for major free-flying spacecraft. Planned missions in 1994 include two launches of the Shuttle Radar Laboratory (SRL), the Light Direction and Ranging (LIDAR), the In-Space Technology Experiment (LITE), and the Atmospheric Laboratory for Applications and Science (ATLAS-3). The LITE is an Advanced Concepts and Technology project with Mission to Planet Earth contribution.

The Space Station Attached Payloads program in Mission to Planet Earth will take advantage of the long-duration, Earth observation opportunities aboard the Space Station. The first attached payload under development is the Stratospheric Aerosol and Gas Experiment III (SAGE III).

The Consortium for International Earth Science Information Network (CIESIN) will increase our understanding of the human dimensions of global change by developing and operating the Socio-economic Data Applications Center (SEDAC) and by providing a framework for the integration of social and natural science data for research.

The Federal Government is committed to the continued acquisition of Landsat-type data for global change research use and other Federal, state, local, and private sector users' needs. The Administration is working to assure existence of a Landsat-7 program that both provides data continuity with previous Landsat data and is affordable in terms of the constrained Federal budget environment.

The long-term ocean color data sets purchased by NASA will contain data useful for research in areas of biological productivity and ecology of oceans, seas, and larger lakes.

The Mission Operations and Data Analysis program collects data from operating Mission to Planet Earth missions. The Upper Atmosphere Research Satellite (UARS) and Ocean Topography Experiment (TOPEX)/Poseidon missions are the most recent launches. The TOMS instrument launched on the Russian Meteor-3 spacecraft in 1991, continues to collect ozone data. The Earth Radiation Budget Experiment (ERBE), launched on the Earth Radiation and Budget Satellite (ERBS) in 1984, continues to provide valuable data on total solar irradiance and its temporal variations.

The Interdisciplinary Research program will continue integrating discipline-specific research activities into a unified program that will help increase our understanding of critical global processes. Specific pilot studies to be conducted include processes for controlling atmospheric methane concentrations, changes in land surface properties and their effect on climate, and the role of oceans in the global carbon cycle.

The Modeling and Data Analysis program focuses on developing predictive models for global change and analyzing data sets to determine mechanisms at work in the global environment. The program emphasizes two major areas: physical climate and hydrological systems, and biogeochemistry and geophysics. Specifically, research will stress the development of coupled global atmosphere-ocean models to diagnose the present climate, to assess impact to the climate of increases in atmospheric trace gases such as carbon dioxide, and in the experimental forecasting of climate on the inter-annual to decadal time scale. Researchers will work to improve techniques for assimilation of satellite data for model initialization and validation.

The Process Studies program will utilize a variety of techniques to develop an understanding of the processes at work in the global environment and to determine interdependencies that may impact global change management strategies. The program will utilize existing data sets and will conduct field experiments that will enable researchers to understand global environmental dynamics. Process studies concentrate on four major interdisciplinary categories: radiation dynamics and hydrology; ecosystem dynamics and biogeochemical

cycles; atmospheric chemistry; and solid Earth science, including operation of the laser research facilities.

The Airborne Science and Applications program continues to provide aircraft based platforms for observing and investigating mechanisms in ozone depleting reactions in the atmosphere over the Arctic and Antarctic. The Airborne program also provides a variety of platforms for diverse studies in oceanography, terrestrial ecology, hydrology, soil studies, tropospheric chemistry, and geology. In addition, the FY 1994 program will focus on a number of international campaigns in Australia (Tropical Oceans Global Atmosphere (TOGA) Program) using the ER-2 and DC-8 aircraft, and Australia and South America for SIR-C precursor studies using the DC-8/AIRSAR (Airborne SAR) system.

The Mission to Planet Earth information system activity will continue supercomputing at the Goddard Space Flight Center (GSFC) and the Jet Propulsion Laboratory (JPL), including upgrades to keep pace with requirements.

The Mission to Planet Earth budget includes programmatic construction of facilities. The Earth systems science building to be located at GSFC will house civil service, contractor, and visiting science personnel conducting global change and Earth science research. Two of the eight EOS Data Information System (EOSDIS) distributed active archive center, one at the Langley Research Center and the other at GSFC, will support EOS and the EOS precursor missions. The FY 1993 budget included funds for the building to house the Consortium for International Earth Science Information Networks.

Education will continue to be an important element of Mission to Planet Earth, with efforts integrated closely with program activities and reviewed on a regular basis. Such efforts prepare the future Earth system science and technical workforce, enhance teacher preparation and understanding of the field, and improve public understanding of, and broaden participation in Earth system science. Specifically, the graduate fellowships in global change research fund approximately 200 graduate students per year in a broad range of scientific investigations. diverse activities - many of them pilot programs - to develop new curriculum, supporting materials, and institutional capability will continue. Other projects actively involve students and teachers in improving skills and knowledge in Earth system science.

BASIS OF FY 1995 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
AM series	180,782	196,659	243,800
PM series	24,631	55,700	78,500
Chemistry	1,251	2,200	5,900
Special spacecraft	12,606	17,425	50,100
Science	44,477	46,792	76,800
Total	263,747	318,776	455,100
Launch vehicles	(2,800)	(16,200)	(55,400)

OBJECTIVES AND STATUS

The objective of the Earth Observing System (EOS) is to acquire a long-term set of comprehensive measurements of various aspects of the Earth system. The EOS program will provide the basis for predictive global climate change models for policy makers' and scientists' use in formulating strategies to mitigate human impacts on global processes such as the greenhouse effect, ozone depletion, and deforestation. The EOS program fulfills the science requirements of the Intergovernmental Panel on Climate Change (IPCC).

The EOS program will provide comprehensive measurements of parameters affecting global climate change. The program includes three U.S. flight series: the morning (AM), afternoon (PM), and Chemistry. The special spacecraft include the Altimetry and Aerosol series, which will depend on international participation, and the possible flights of some instruments on Japanese, European, and other international spacecraft. The EOS also includes an ocean color data purchase. The science budget supports interpretation of the collected data. The AM, PM, and Chemistry flight series will be designed to last five years, flying three times, making measurements over fifteen-year periods. The AM series science objectives are to measure physical and radiative properties of clouds; air-land exchanges of energy, carbon, and water; and vertical profiles of carbon monoxide and methane. The PM series will study cloud formation, precipitation, and radiative properties; air-sea fluxes of energy and moisture; and sea-ice extent and heat exchange with the atmosphere. The remaining EOS missions will examine aerosol and chemical properties of the troposphere and stratosphere, ocean altimetry and circulation, and ice sheet mass balance.

The EOS missions will monitor many parameters that are indicators of the state of the environment, such as the spatial and temporal distribution of tropospheric and lower stratospheric gases. In addition, interdisciplinary theoretical investigations will utilize EOS data sets and complementary data sets to study such phenomena as ecosystem distributions and conditions; biogeochemical fluxes at the ocean-atmosphere and land-atmosphere interfaces; the global carbon cycle; and atmospheric composition.

The AM-1 program has concluded the Preliminary Design Review (PDR) phase with the system-level observatory PDR in September 1993. In preparation for the system-level PDR, all AM-1 instruments completed PDR's. The last instrument to enter Phase C/D, the Canadian Space Agency-supplied Measurement of Pollution in the Troposphere (MOPITT), held an interface PDR in the summer of 1993, followed by a full PDR in December 1993. The AM-1 is now entering its Critical Design Review (CDR) phase; the U.S. supplied instruments began CDR with the Clouds and the Earth's Radiant Energy System (CERES) in December 1993, to be followed by the Moderate-Resolution Imaging Spectrometer (MODIS) in the second quarter of 1994. The spacecraft component and subsystem CDR's and the AM-1 launch vehicle selection are scheduled to begin by the third quarter. These activities will lead to the system-level CDR in FY 1995.

Technical progress under way on AM-1 includes the technology demonstration of the Capillary-Pumped Heat Transport System flight experiment (CAPL) on STS-60 and the radiation testing of the new memory storage chips for the solid state recorder, a baseline change effected last year to take advantage of new technology available in the commercial sector. Engineering models of the three U.S. instruments are currently in fabrication, assembly, or test to support the CDR's. Refurbishment of the engineering models, or fabrication of new hardware, for protoflight units will begin before the end of the 1994.

Current Phase B studies of the PM-1/Chemistry-1/AM-2 common spacecraft observatories have been extended in order to consider alternative configurations that allow the use of medium-sized launch vehicles. The extended studies are expected to come to a close in FY 1994, leading to the release of a Request For Proposal (RFP). Activity on the instruments include the continuation of Phase B studies, particularly the Microwave Limb Sounder (MLS), which is considered a technologically demanding effort. Notable progress has been achieved on the cooler development in support of the Atmospheric Infrared Sounder (AIRS) instrument, and successful demonstrations at more than one vendor are anticipated before the end of FY 1994. Other activities include a search for an alternative source for the Microwave Humidity Sounder (MHS) or equivalent instrument (originally being provided by an international partner). NASA is studying alternative configurations for the small spacecraft series, Altimetry, in concert with the science community.

The EOS PM and related spacecraft bus detailed definition phase was extended to permit further consideration of spacecraft configurations compatible with a medium-class expendable launch vehicle (ELV). If this approach is determined to be technically feasible and consistent with EOS program requirements, the MELV-

compatible approach would be reflected in reduced funding estimates for launch vehicles and a revised cost and schedule plan consistent with the application of savings to the EOS program. The current program scheduled and funding plans assume a larger spacecraft platform and commensurately sized ELV.

Science activity, especially within the AM-1 program, has shown progress in defining the standard data products to be produced by EOS. A baseline set is now currently documented within the EOS Project Plan, and will be verified by the investigators in FY 1994. The science budget provides for the EOS ocean color data purchase. The algorithms, which interpret the radiance data into geophysical parameters, are entering the early design stage, paced by design maturity of the instruments and the delivery of the product generation system toolkits from EOS Data Information System (EOSDIS).

BASIS OF FY 1995 ESTIMATE

Most activity during FY 1995 will be concentrated on final design of AM-1, the flight of opportunity instruments, and the science algorithms. On AM-1, NASA will complete the CDR's for the spacecraft subsystems and instruments, so final designs can be verified at the system-level CDR in the second quarter of FY 1995. Also in FY 1995, the flight software CDR will be completed. In FY 1995, assembly of subsystem components will be completed for the power, electrical, thermal control, guidance, and navigation. NASA will test the subsystems in preparation for spacecraft integration and test in FY 1996. The flight units of two of the U.S.-made instruments (MODIS and CERES) will also complete assembly and test. Calibration of the engineering model of Multi-Angle Imaging Spectrometer (MISR), the third U.S. instrument, will be accomplished, and parts for the protoflight unit will be procured. Phase B and preliminary design activities will continue on the instruments planned for the PM-1 and Chemistry flights.

Two EOS flight of opportunity instruments will be delivered to the Tropical Rainfall Measurement Mission (TRMM) program in FY 1995, the protoflight unit for CERES and the Lightning Imaging Sensor (LIS). A third flight of opportunity instrument, SeaWinds (formerly called NASA Scatterometer II) will complete instrument subsystem (i.e., antenna, power supply) CDR's in preparation for the instrument CDR in FY 1996, for delivery to the Japanese Advanced Earth Observing System II (ADEOS II) program.

The AM-1 science teams will deliver the preliminary "beta" version of the science algorithms to the EOSDIS, and procurement will be under way for the ocean color data purchase, which will ensure data coverage after 1998 and before the PM-1 launch.

The increase from FY 1994 to FY 1995 accommodates the planned increase in EOS work leading to first launch in 1998, offset by reductions to support contractor and the transfer of Small Business Innovative Research to Advanced Concepts and Technology.

BASIS OF FY 1995 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM DATA INFORMATION SYSTEM

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Earth observing system data information system	130,688	188,158	284,900

OBJECTIVES AND STATUS

A key element enabling Earth Observing System (EOS) to meet the program's long-term science goals, and those of Mission to Planet Earth, is the EOS Data and Information System (EOSDIS). The EOSDIS will provide the processing, storage, and distribution of the EOS science data and the resulting scientific products. The EOSDIS system will also have the capability for spacecraft and instrument command and control. Additionally, EOSDIS will provide data archive and distribution and information management for all NASA Mission to Planet Earth data.

The EOSDIS will be evolutionary, with capability phased to support the requirements of the rescoped EOS program and those of other Mission to Planet Earth spacecraft and data sources. The Distributed Active Archive Centers (DAAC's) will perform continuous processing of instrument data to derive the underlying scientific parameters of interest. The network will link the archived data and products so that investigators may access the entire set of holdings from any entry point. An information management service will help users locate data within the total archive. The network also will interface with international partner instruments and control facilities and will provide data to operational agencies such as the National Oceanic and Atmospheric Administration (NOAA).

The EOSDIS includes the development of operational ground systems for spacecraft and instrument command and control, the EOS Data Operations System (EDOS) and the EOS Communications System (ECOM). These systems accept data from the Tracking and Data Relay Satellite System (TDRSS) ground terminal, process it, and deliver data products to the DAAC's and control centers through the EOSDIS. The EOSDIS also provides for the Independent Verification & Validation (IV&V) of the EOSDIS core system.

The Version 0 prototype has been successfully demonstrated to the DAAC user working groups and several other test users. Demonstrated functions included the browse product generation, the data dictionary, graphical user interface, and integration with the Global Change Master Directory (GCMD). All of the original DAAC's are now on-line: the Consortium for International Earth Science Information Network (CIESIN) role as the

socio-economic data center is being further refined, and the Version 0 Information Management System (IMS) will be ported to the Oak Ridge National Laboratory DAAC in FY 1994.

All Version 0 work is on schedule for the major milestone of an operational Version 0 prototype with final architecture in the third quarter of 1994. The operational prototype will make available to all researchers the first Earth science view of aggregate DAAC holdings, with the same view available from any and all of the DAAC's. This will include a product request graphical user interface with cross-DAAC inventory search, coordinated user services and 259 NASA data sets, including the first pathfinder products. Other pathfinder data sets in work are reprocessing data from operational NOAA and military instruments, as well as NASA research instruments, to create long time-series of global and regional data sets of higher-level geophysical parameters.

The EOSDIS Core System (ECS) development is now under way with a System Requirements Review (SRR) held in FY 1993. As a result of the issues raised at SRR, two universities will perform independent ECS architecture studies, beginning in January 1994. Other progress within ECS has been the product generation system toolkits, needed by the science teams to develop the science software used by EOSDIS to produce the geophysical parameters from the EOS instruments. Specifications for the toolkits have been delivered to the science teams, and phased deliveries of the actual toolkits themselves will begin in late FY 1994.

Contract selection to awards for both the EDOS and the IV&V projects occurring in FY 1994. The EDOS project will hold SRR later in FY 1994, while the IV&V contractor will assume responsibility for the requirements database in preparation of testing the ECS releases beginning in FY 1995. In-house EOS Communications (ECOM) activities will include a system design review and preliminary design review. A request for proposal for commercial communications software will be released in FY 1994 for an award later in the year.

BASIS OF FY 1995 ESTIMATE

Funding is needed in FY 1995 to support the development of the EOSDIS Core System (ECS) as the project enters the first release cycle. Release A, which will be complete in FY 1996, will initiate the transition from the Version 0 prototype at four of the DAAC's and support the pre-EOS mission data products from TRMM, Landsat, and the ocean color data purchase. Also in FY 1995, the final product generation system toolkits for algorithm development will be delivered to the scientists for use on the science computing facilities at both the flight science teams and interdisciplinary investigators. The science computing facilities, also funded by EOSDIS, will continue to upgrade the computing resources needed by the science investigators to develop the science algorithms.

Other aspects of EOSDIS which will be in work during FY 1995 are the EDOS, scheduled for a Preliminary Design Review (PDR), and ECOM, scheduled for both a Critical Design Review (CDR) and a test readiness review. With both these systems coming together for interface testing in FY 1996, FY 1995 will be a crucial

year for detailed design. In addition, the ground systems integration plan will be finalized and a test plan prepared for the following year activities. The IV&V contractor will assume the important function of verifying ECS Release A, while the interim releases to the DAAC's improve the ability to incorporate operational feedback.

The increase from FY 1994 to FY 1995 accommodates the planned increase in EOSDIS work to early EOS missions and the pre-EOS mission data products, offset by reductions to support contractor and the transfer of Small Business Innovative Research to Advanced Concepts and Technology.

BASIS OF FY 1995 FUNDING REQUIREMENT

EARTH PROBES

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
NASA scatterometer	20,200	18,700	15,400
Total ozone mapping spectrometer	27,685	11,000	16,500
Tropical rainfall measurement mission	51,528	66,726	50,100
Total	99,413	96,426	82,000
Launch vehicle (TOMS)	(1,900)	(1,500)	(--)

OBJECTIVES AND STATUS

The Earth Probes program is the component of Mission to Planet Earth that addresses specific, highly-focused problems in Earth science research. The program has the flexibility to take advantage of unique opportunities presented by international cooperative efforts or technical innovation. The Earth Probe missions complement the Earth Observing System program by providing the ability to investigate processes that require special orbits or have unique requirements. The currently approved Earth Probes are the Total Ozone Mapping Spectrometer (TOMS), NASA Scatterometer (NSCAT), and Tropical Rainfall Measurement Mission (TRMM).

The TOMS Scatterometer program consists of a set of instruments (Flight Models 3, 4, and 5, designated FM3, FM4, and FM5) and one spacecraft for launch on a small-class expendable launch vehicle in mid FY 1994 (FM3), and for launch on the Japanese Advanced Earth Observing System (ADEOS) satellite in 1996 (FM4). A third instrument (FM5) will be available in 1995 for a flight of opportunity in 1998. The TOMS instrument flights will provide uninterrupted data on total atmospheric ozone concentrations. The TOMS flights build on the experience that began in 1978 with the launch of a TOMS instrument (FM1) on Nimbus-7 and continues with the TOMS instrument (FM2) on the Russian Meteor-3, launched in 1991.

The NSCAT will provide accurate, global measurements of ocean surface winds, useful for both oceanography and meteorology. In addition, NSCAT data will permit the first global study of the influence of winds on ocean circulation, providing data on the effects of the oceans on the atmosphere and improved marine forecasting on winds and waves. The NSCAT will also fly on the Japanese ADEOS satellite in 1996.

The TRMM spacecraft will measure precipitation in the tropical latitudes from a dedicated Earth Probe. The U.S. will provide the spacecraft, integration, and four instruments. The Japanese will provide the 1997 launch and a precipitation radar.

BASIS OF FY 1995 ESTIMATE

The FY 1995 NSCAT and TOMS funding supports ADEOS spacecraft integration and testing in Japan. Funding is also required for continued development of the NSCAT science data processing system. The TRMM FY 1995 funding is required to complete development of the U.S.-provided instruments and the spacecraft subsystems. Observatory integration and test will begin in FY 1995, and design and development of the TRMM science data and information system will continue.

The decrease from FY 1994 to FY 1995 accommodates the planned completion of currently approved Earth Probes, offset by reductions to support contractor and the transfer of Small Business Innovative Research to Advanced Concepts and Technology.

BASIS OF FY 1995 FUNDING REQUIREMENT

SPACE STATION ATTACHED PAYLOADS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Stratospheric aerosol and gas experiment III....	--	--	9,800

OBJECTIVES AND STATUS

The Space Station Attached Payloads program in Mission to Planet Earth is an ongoing effort to develop Earth-observing payloads to fly aboard the Space Station, taking advantage of the long-duration platform with servicing performed by the crew. The flight experiment hardware and science support will be funded in the Mission to Planet Earth budget. The first attached payload under development is the Stratospheric Aerosol and Gas Experiment III (SAGE III).

The SAGE III instrument will obtain global profiles of aerosols, ozone, and other atmospheric constituents, as well as temperature and pressure profiles in the mesosphere, stratosphere, and troposphere. The SAGE III is a natural and improved version of the SAGE I and SAGE II experiments. The additional wavelengths and lunar occultation (in addition to solar occultation) that SAGE III provides will improve aerosol characterization, improve and expand the retrieval of other gaseous components, extend the vertical range of measurements, and provide a self-calibrating capability. The resultant data will be used to study the role of aerosols, gaseous atmospheric constituents and ozone chemistry in the Earth's climatological processes.

BASIS OF FY 1995 ESTIMATE

The FY 1995 budget is necessary to start development of SAGE III. The contract for the SAGE will be modified in FY 1994 for the Space Station SAGE III, with the Phase C/D beginning in FY 1995. The flight instrument will be delivered in 1997 for the Space Station. The experiment is planned for flight in 1999.

BASIS OF FY 1995 FUNDING REQUIREMENT

ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITE

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Advanced communications technology satellite....	3,968	3,000	2,300
Upper stage....................................	(17,700)	(--)	(--)

OBJECTIVES AND STATUS

The Advanced Communications Technology Satellite (ACTS) program maintains U.S. leadership in the communications satellite market through the development and flight verification of advanced technologies that enhance the capability of communications satellites.

The U.S. user community, representing some 85 private sector organizations, universities and other government agencies, is conducting experiments to test and evaluate the ACTS technologies under various applications scenarios. The key ACTS technologies include high gain power, fast-hopping multiple beam antenna; on-board intermediate frequency and baseband switching; wide bandwidth (1 GBPS) transponders, Ka-band components; and dynamic rain fade compensation techniques.

The transfer of the ACTS technology to the industry is proceeding. Commercial systems which are being built using ACTS technology are a global mobile communications system called Iridium by Motorola (the developer of the ACTS on-board switching), the video phone system by Hughes, the global fixed service system by Calling Communications and the home video system by Norris Communications.

The ACTS satellite was successfully deployed from STS-51 on September 12, 1993, and arrived on-station in geostationary orbit approximately two weeks later. The satellite, the master control station and multiple Earth stations have been checked out. By January 1994, the experiment period will begin during which 78 experiments are scheduled to utilize ACTS technologies.

BASIS OF FY 1995 ESTIMATE

The FY 1995 budget provides for the continuation of mission operations at the Lewis Research Center. The ACTS experiments program is funded and conducted under the Commercial Use of Space program.

The decrease from FY 1994 to FY 1995 accommodates the planned completion of the ACTS two-year operations.

BASIS OF FY 1995 FUNDING REQUIREMENT

PAYLOAD AND INSTRUMENT DEVELOPMENT

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Atmospheric payloads	12,330	11,712	8,700
Earth sensing payloads	23,131	11,188	10,800
Total	35,461	22,900	19,500

OBJECTIVES AND STATUS

The objective of Atmospheric Payloads is to provide information related to the chemical constituency and dynamics of the Earth's atmosphere. The objective of the Earth Sensing Payloads is to demonstrate the technology and algorithms needed to make multi-frequency, multi-polarization active radar measurements of the Earth's surface (i.e., land, sea, and ice). Together, the two programs will provide measurements crucial to enhancing the understanding of the role of the Earth's atmosphere and surface during global change.

The Space Shuttle offers a unique opportunity for short-duration flights of instruments. The Mission to Planet Earth program has incorporated this capability into the Shuttle/Spacelab payload development in these important areas: design, early test, and checkout of remote sensing instruments for long-duration, free-flying missions and short-term atmospheric and environmental data gathering for basic research and analysis where long-term observations are impractical. Instrument development activities support a wide range of instrumentation, from airborne to international flights of opportunity.

The objective of the Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS) experiment is to make detailed measurements of gaseous constituents (i.e., hydrogen chloride, water, ammonia, and methane) in the Earth's atmosphere by using the technique of infrared absorption spectroscopy. The data will help determine the compositional structure of the upper atmosphere, including the ozone layer and its spatial variability on a global scale. The instrument first flew in 1985 on Spacelab-3 and again on Atmospheric Laboratory for Applications and Science 1 (ATLAS-1) in 1992 and ATLAS-2 in 1993. The science results from these flights of ATMOS were of exceptional value, and the basic capability of ATMOS to measure very low concentrations of trace species in the Earth's atmosphere was clearly demonstrated. The instrument is to fly again on ATLAS-3 in 1994.

The Shuttle Imaging Radar-C (SIR-C) in combination with the X-band Shuttle Aperture Radar (X-SAR) contributed by German and Italy will explore regions of Earth's surface, many of which are not well characterized because of vegetation, cloud, or sediment cover. These radar studies will lead to a better understanding of ocean and land surface, and subsurface processes on a global scale. Currently, SIR-C is at the Kennedy Space Center (KSC) being integrated into the orbiter with two launches aboard the Space Shuttle scheduled for 1994.

The Measurement of Air Pollution from Satellites (MAPS) experiment is a gas filter correlation radiometer designed to measure the levels of troposphere carbon monoxide in the troposphere and the extent of inter-hemispheric mass transport in the lower atmosphere. The instrument has flown successfully on two Shuttle flights. It is planned for two more Shuttle Radar Laboratory (SRL) flights in 1994 to provide the first observations of the global seasonal variation of carbon monoxide in the Earth's atmosphere.

The Light Direction and Ranging (LIDAR) In-Space Technology Experiment (LITE) is an advanced technology Earth atmosphere sensing experiment. The laser application will provide measurements of higher resolution and accuracy than current spaceborne instruments of stratospheric and tropospheric aerosols, planetary boundary layer heights, and cloud top temperature and density.

Like LITE, the LIDAR Atmospheric Sensing Experiment (LASE) is also an advanced technology Earth atmospheric sensing experiment. Starting in FY 1994, NASA plans to fly the instrument routinely on the ER-2 aircraft to obtain water vapor measurements with better resolution and accuracy than current instruments. These measurements will support studies in global hydrology, meteorology, radiation budget, climate and atmospheric transport, and chemistry.

The Solar Ultraviolet Spectral Irradiance Monitor (SUSIM) is designed to make very accurate measurements of the sun's ultraviolet radiation, which is the primary sources of energy for the Earth's atmosphere. The SUSIM has flown on four previous STS flights and is planned for reflight on ATLAS-3 in 1994.

The Shuttle Solar Backscatter Ultraviolet (SSBUV) instrument provides correlative measurements with SBUV/2 instruments that fly on NASA and NOAA spacecraft. Both instruments measure the amount and height distribution of ozone in the upper atmosphere. These measurements help resolve any data reliability problems resulting from calibration drift. The SSBUV is planning to continue flights on the Shuttle through the rest of the decade.

The Active Cavity Radiometer-1 (ACR-1) is designed to aid in the study of the Earth's climate and the physical behavior of the sun by making solar constant measurements. Reflight of ACR-1 is planned for 1994 on ATLAS-3.

Advanced spectrometer technology development activities include fundamental research in remote sensing involving airborne and spaceborne imaging spectrometer instruments. The imaging spectrometer and linear array solid-state sensor research focuses on the development of such features as inherent geometric and spectral registration and programmable high spatial and spectral resolution.

BASIS OF FY 1995 ESTIMATE

The FY 1995 funds will be used to support the integration of the Measurement of Air Pollution from Satellites (MAPS) instrument onto Shuttle compatible instrument canisters for future flights of opportunity. Funding for ATMOS, ACR-1, and SUSIM is required to support the post ATLAS-3 mission calibration, science team and science data reduction, and the deactivation of the instruments. The SSBUV/A instrument will be flown again in 1995 in support of the continuing mission to monitor the Earth's ozone status. In 1995, the LIDAR program will be completing its development and science validation of the LASE instrument, and initiate the study and development of new science instruments that will utilize the capabilities of NASA aircraft such as the ER-2 and new Remotely Piloted Vehicles currently under development. The SIR-C and LITE experiments will be returned from the KSC for checkout and storage. The remainder of FY 1995 will be devoted to processing SIR-C data.

The decrease from FY 1994 to FY 1995 accommodates the planned completion of currently approved payload and instrument development, offset by reductions to support contractor and the transfer of Small Business Innovative Research to Advanced Concepts and Technology.

BASIS OF FY 1995 FUNDING REQUIREMENT

OCEAN COLOR MISSION DATA PURCHASE

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Ocean color mission data purchase..............	15,570	3,400	600

OBJECTIVES AND STATUS

NASA is purchasing ocean color data for research use, with payments phased before and after launch. The data will be from the Sea-Viewing Wide Field Sensor (SeaWiFS) instrument to be launched on the SeaStar spacecraft in 1994. This imaging data, which will be obtained in several visible and infrared wavelengths, will be processed and archived, resulting in long-term data sets related to the biological productivity and ecology of the world's oceans, seas, and larger lakes.

BASIS OF FY 1995 ESTIMATE

The FY 1995 funding is for data purchase from the contractor (Orbital Sciences Corporation); the post-launch NASA ground processing, further data purchase cost and scientific analysis is funded in mission operations and data analysis.

The decrease from FY 1994 to FY 1995 is based on the end of development and planned launch.

BASIS OF FY 1995 FUNDING REQUIREMENT

CONSORTIUM FOR INTERNATIONAL EARTH SCIENCE INFORMATION NETWORKS

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Consortium for international earth science information networks	18,000	5,000	6,000

OBJECTIVES AND STATUS

The overall goal of Consortium for International Earth Science Information Network (CIESIN) is to increase our understanding of the human dimensions of global change by developing and operating the Socio-economic Data Applications Center (SEDAC) and by providing a framework for the integration of social and natural science data for research. The CIESIN will facilitate the access to and use of Mission to Planet Earth data for Earth science research and public policy making. The SEDAC serves as an affiliated data center for NASA's Earth Observing System Data Information System program.

BASIS OF FY 1995 ESTIMATE

The FY 1995 funding for CIESIN will continue the research with the combination of socio-economic data and derived Mission to Planet Earth science products. The CIESIN will continue the SEDAC system for research by use by the socio-economic research community.

The increase from FY 1994 to FY 1995 accommodates the planned workload.

BASIS OF FY 1995 FUNDING REQUIREMENT

LANDSAT

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Landsat	25,000	54,100	62,400

OBJECTIVES AND STATUS

The Federal Government is committed to the continued acquisition of Landsat-type data for global change research and other Federal, state, local, and private sector users' needs. NASA and the Department of Defense (DoD) undertook development of Landsat-7 flight and ground segments in March 1992, as established in the DoD and NASA Management Plan for the Landsat program. The contract for procuring Landsat-7 flight segment was awarded by the DoD in October 1992.

The Administration is working to assure a Landsat-7 program that both provides data continuity previous Landsat data and also is affordable in terms of the constrained Federal budget environment.

BASIS OF FY 1995 ESTIMATE

The FY 1995 funding is the total amount available for the NASA Mission to Planet Earth portion of the Landsat-7 program. The estimate covers development of the ground segment (ground processing and mission operations systems) and continuation of a Tracking and Data Relay Satellite System communication antenna for the Landsat-7 satellite, contingent resolution of the implementation management issues and reaching agreement on a flight system configuration.

The increase from FY 1994 to FY 1995 accommodates the planned increase in Landsat work.

BASIS OF FY 1995 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Upper atmosphere research satellite operations..	35,963	30,308	30,000
Ocean topography experiment operations..........	31,614	31,052	32,100
Total ozone mapping spectrometer................	1,101	3,186	3,700
Ocean color mission data analysis...............	--	6,500	6,100
Earth science mission operations and data analysis	25,305	26,398	25,600
Total..................................	93,983	97,444	97,500

OBJECTIVES AND STATUS

The objective of the Earth Science Mission Operations and Data Analysis program is to acquire, process, and archive long-term data sets. These data relate to issues of global change research in atmospheric ozone and trace chemical species, the Earth's radiation budget, aerosols, sea ice, land surface properties, and ocean circulation and biology. Funding provides for operations of spacecraft, processing of acquired data, validation of the resulting data products by science teams, and development of new processing software by these science teams.

The Upper Atmosphere Research Satellite (UARS) was launched in September 1991. The mission is providing data related to the chemistry and dynamics of the atmosphere above the tropopause for a period of at least three years. Various instruments aboard UARS are measuring temperature, composition, and winds in the Earth's atmosphere, as a function of altitude, over 98% of the Earth's surface, from eighty degrees South latitude to eighty degrees North. These data will provide important information related to the maintenance and destruction of the ozone layer. Correlative measurements are a key element of the UARS science objectives. Ground-based, balloon, and sounding rocket measurements of the atmosphere are used to validate and calibrate UARS instrument measurements, refining the accuracy of the derived geophysical parameters. All UARS instruments are operational except for the Cryogen Limb Array Etalon Spectrometer (CLAES) which exhausted its cryogen in May 1993, and the United Kingdom's Improved Stratospheric and Mesospheric Sounder (ISAMS), which failed in July 1992.

NASA's Ocean Topography Experiment (TOPEX) and the French Poseidon mission were launched as a single ocean spacecraft mission, TOPEX/Poseidon, in August 1992. This mission will provide data on the surface

topography and currents of the Earth's oceans for a period of at least five years. These data, in conjunction with the Scatterometer data, will enable the first determination of the wind forcing and ocean current response of the global oceans.

Data from the Earth Radiation Budget Satellite's (ERBS) (which was launched in 1984), Stratospheric Aerosol and Gas Experiment II (SAGE-II), continue to provide vertical profiles of aerosols, ozone, and other trace gas species over the Earth's tropical and mid-latitude regions.

The Earth Radiation Budget Experiment (ERBE) is comprised of three identical instrument packages flying on NOAA-9, NOAA-10, and NASA's ERBS. These instruments continue to provide data on the temporal and spatial variations in the Earth's radiation budget, which drive the Earth's climate. The ERBE instruments provide the only continuous data set on total solar irradiance (solar constant) and its temporal variations stretching from 1978 to the present.

In December 1993, the Nimbus-7 spacecraft orbit geometry degraded beyond recovery and scientific use of the mission ceased.

Data from the Solar Backscatter Ultraviolet/2 (SBUV/2) instruments, on the NOAA-9 and NOAA-11 satellites, provide column abundances and vertical profiles of atmospheric ozone beneath the orbital tracks of these satellites, continuing the collection of a data set begun with the SBUV instrument on Nimbus-7 in 1978. A carefully calibrated version of the same instrument, called Shuttle SBUV (SSBUV), has been flown five times on the Space Shuttle and will continue to fly periodically throughout the 1990's. The SSBUV provides correlative measurements so that the Total Ozone Mapping Spectrometer (TOMS) and SBUV instruments flying on other spacecraft can be more accurately calibrated, and provides information on the diurnal variability of stratospheric ozone in low latitudes.

NASA's Alaska Synthetic Aperture Radar Facility (ASF), based at the Geophysical Institute at the University of Alaska in Fairbanks, began acquisition and processing of Synthetic Aperture Radar (SAR) data transmitted from the European Space Agency's Earth Remote Sensing Satellite-1 (ERS-1) in early 1991 and the Japanese Earth Remote Sensing Satellite-1 (JERS-1) in mid-1992. Data from the Canadian RadarSat spacecraft will also be acquired and processed after its launch in 1995. These data will provide important information on the properties and dynamics of sea ice and other land and ocean processes in the polar regions.

The Optical Transient Detector (OTD) will provide early acquisition of science data to support research in determining global distribution of lightning and its affects on climate change. The FY 1994 launch of the OTD will also allow for an early engineering flight of the Earth Observing System Lightning Imaging Sensor (LIS) instrument and concept validation, including the high speed solid-state camera system and real-time event processor, and will be a pathfinder for commercial remote sensing applications of lightning data.

BASIS OF FY 1995 ESTIMATE

Operations of the TOPEX spacecraft and processing and analysis of its data will continue. Operation of the UARS spacecraft will continue until the end of FY 1995. Processing and analysis of data from the TOMS instrument flying on the Russian Meteor-3 spacecraft and on the TOMS Earth Probe mission will continue. Operation and data processing of ERBS spacecraft will continue, as will processing and analysis of data from NOAA-based and Shuttle-based SBUV instruments. Processing and analysis of SAR data acquired at the ASF from European Space Agency's ERS-1 will also continue and be augmented by similar processing and analysis of SAR data from Japan's JERS-1. For the ocean color purchased data, FY 1995 funding provides for the NASA ground processing and scientific analysis.

The change from FY 1994 to FY 1995 accommodates planned flight program progress, offset by reductions to support contractor and the transfer of Small Business Innovative Research to Advanced Concepts and Technology.

BASIS OF FY 1995 FUNDING REQUIREMENT

INTERDISCIPLINARY RESEARCH AND ANALYSIS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Interdisciplinary research and analysis.........	4,453	5,000	4,600

OBJECTIVES AND STATUS

Interdisciplinary research activities are conducted to characterize quantitatively the Earth's chemical, physical, and biological processes on the land, along with the interactions between the land, the oceans, and the atmosphere, which are of particular importance in assessing the impact of these phenomena on global, physical, and biogeochemical processes. Such research is essential to investigating and assessing long-term physical, chemical, and biological trends and changes in the Earth's environment. Included in the program activities are joint efforts from a variety of disciplines, such as atmospheric science, climatology, biological sciences, geochemistry, and oceanography.

BASIS OF FY 1995 ESTIMATE

In FY 1995, interdisciplinary studies will be continued with emphasis on integrating discipline-specific research activities of oceanic processes, atmospheric dynamics and radiation, upper atmosphere/troposphere chemistry, and land processes into a unified program which will help increase our understanding of critical global processes. Emphasis will be placed on specific studies that will increase the understanding of the sources, transport and affects of tropospheric aerosols on the climate system.

The decrease from FY 1994 to FY 1995 is due to the effects on research and analysis programs of the general downsizing of the NASA budget in addition to the transfer of Small Business Innovative Research to Advanced Concepts and Technology.

BASIS OF FY 1995 FUNDING REQUIREMENT

MODELING AND DATA ANALYSIS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Physical climate and hydrologic systems modeling and data analysis	26,862	26,532	25,600
Biogeochemistry and geophysics modeling and data analysis	15,709	17,713	15,600
Total	42,571	44,245	41,200

OBJECTIVES AND STATUS

The research and analysis activities within the Modeling and Data Analysis program provide a focus for contributing to an improved understanding of the fully-integrated geophysical climate system, its interactions and predictability, through the development and multi-disciplinary exploitation of global satellite observations of the Earth, numerical modeling, climate impact assessments, and sensitivity studies. The two principal components of the program are climate modeling research and climate data analysis.

The objectives of the Physical Climate and Hydrologic Systems Modeling Research program are to develop and improve global circulation models which assimilate and optimize the use of satellite-derived data sets for understanding climate interactions; to help guide the design of the global observing system, and to improve the capability for reliable climate diagnosis and forecasting. The program builds on the broad foundation established over the past decade of research on geophysical modeling conducted under the NASA atmospheric dynamics and radiation and ocean processes programs.

The objectives of the Physical Climate and Hydrologic Data Analysis program are to assemble a long-term global record of climate parameters, with an emphasis on satellite remote sensing, for specifying and analyzing the state of the climate system and its variability. These include the full range of geophysical variables which describe the structure and composition of the atmosphere, oceans, land surfaces, and cryosphere, as well as their boundaries, interfaces, and external forcings. The program builds on earlier accomplishments achieved through such diverse research initiatives as the International Satellite Cloud Climatology Project (ISCCP), the Earth Radiation and Budget Experiment (ERBE), the Global Atmospheric Research Program (GARP) and current activities in support of the Tropical Oceans Global Atmosphere (TOGA) Program and the World Ocean Circulation Experiment (WOCE). These programs are elements of the World Climate

Research Program (WCRP), sponsored by the World Meteorological Organization and the International Council of Scientific Unions. Such international relationships are strongly encouraged by the U.S. Global Change Research program plan.

The Biogeochemistry and Geophysics Modeling and Data Analysis has as its objectives the development of global change models dealing with all aspects of the biology, chemistry, geology, and geophysics of the Earth system, with the exploitation of satellite data in the monitoring of global change as well as the study of the mechanisms which are at work in the global environment. There are four major elements of the program: ocean biogeochemistry, atmospheric chemistry, geophysical modeling and analysis, and ecology and land atmosphere interactions.

In the ocean biogeochemistry area, the emphasis is on data analysis efforts utilizing existing satellite data sets to understand better the variations in ocean productivity and preparing improved algorithms and data systems for the Ocean Color Mission.

The atmospheric chemistry area is centered on the numerical modeling and analysis of measurements of trace constituents in the troposphere-stratosphere system. Numerical models are used to test our understanding of atmospheric chemistry and of the way in which meteorological processes affect the trace constituent distribution in the atmosphere. Models are also used to predict future changes to the chemical composition of the atmosphere.

Research in geophysical modeling and analysis consists of modeling and analysis of the Earth's internal structure and dynamics, and interactions with the atmosphere and hydrosphere, through measurements of the gravitational and magnetic fields, Earth rotation and polar motion observations, and geodetic properties. The spatial variability of the potential fields and the temporal variability of the motion fields are the critical observational parameters.

In the ecology and land atmosphere interactions area, global scale observations are analyzed to understand the current state of terrestrial ecosystems, to assess their natural variability, and to determine the impacts of anthropogenic forcings. Numerical models and multi-temporal satellite observations are used to study sources and sinks of biogeochemical species and to investigate the interactions of climatic events such as El Niño with surface biology and atmospheric composition. Theoretical modeling of ecosystem functioning and land atmosphere interactions is conducted using global circulation models with explicit, interactive biospheres.

BASIS OF FY 1995 ESTIMATE

The climate modeling program element will continue emphasis on developing the individual components and integration of a fully interactive Earth system model that can be used in a wide range of climate impact assessment studies. Further emphasis will be placed on developing model-based data assimilation techniques capable of ingesting and processing the latest generation of satellite remote sensing and conventional data to produce research quality geophysical data sets.

The data analysis program element will stress continued analysis and applications of satellite data from the Upper Atmosphere Research Satellite (UARS), the Ocean Topography Experiment (TOPEX), the Earth Radiation Budget Experiment (ERBE), Meteor/TOMS, TOMS/Earth Probe, and other flight data sets to contemporary scientific problems such as ozone depletion and global climate change. A new emphasis will be placed on utilization of data sets produced by the pathfinder project, especially the Advanced Very High Resolution Radiometer (AVHRR) and TOMS data.

The decrease from FY 1994 to FY 1995 is due to the effects on research and analysis programs of the general downsizing of the NASA budget in addition to reductions to support contractor and the transfer of Small Business Innovative Research to Advanced Concepts and Technology.

BASIS OF FY 1995 FUNDING REQUIREMENT

PROCESS STUDIES

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Radiation dynamics and hydrology	31,560	34,325	31,800
Ecosystem dynamics and biogeochemical cycles	23,679	26,511	25,400
Atmospheric chemistry	28,111	31,651	25,700
Solid earth science	27,680	28,128	28,900
Laser research facilities	8,225	9,052	7,600
Total	119,255	129,667	119,400

OBJECTIVES AND STATUS

The research and analysis activities within the Radiation Dynamics and Hydrologic Processes program combine a core effort of theoretical, laboratory, and field investigations essential to understanding the basic geophysical processes and their interactions which control climate. The two principal components of the program are in the areas of radiation and dynamic processes research and hydrologic processes research.

The objectives of the Radiation and Dynamics Research program are to improve our understanding of the basic physical processes by which the atmospheric system absorbs, transforms, stores and transports energy. Understanding atmospheric dynamics and radiation as well as the water cycle processes is essential to determinations of how the atmosphere behaves and its role in determining climate and climate change.

The objectives of the Hydrologic Processes Research program are to improve our understanding of the physical processes which govern the hydrological cycle and its impact on the atmosphere, cryosphere, and oceans. The prediction of global change in the geosphere and biosphere will be one of the most important problems in environmental sciences in the twenty-first century. Estimation of the distribution and transport of carbon, nitrogen, sulfur, etc., cannot be obtained without knowledge of the atmospheric circulation and water cycle on regional and global scales.

The Ecosystem Dynamics and Biogeochemical Cycles program conducts research on the function of global ecosystems and the interactions of the Earth's biota with the atmosphere and hydrosphere. Particular emphasis is placed on understanding land atmosphere interactions and the carbon cycle. The two principal components of the program are the ecosystem dynamics program element and the biogeochemical processes program element.

The goal of the ecosystem dynamics program element is to achieve an improved understanding of the role of the biosphere and the biologically-linked components of the hydrologic cycle in processes of global significance. Specific objectives are to develop understanding of the ecological controls on the exchanges of energy, water, and nutrients between ecosystems and the atmosphere, the response of ecosystems to change, and the biophysics of remote sensing of ecosystem properties.

The goal of the biogeochemical processes program element is to achieve an improved understanding of the sources, sinks, fluxes, trends, and interactions involving the biogeochemical constituents within the Earth system, with an emphasis on their major biospheric reservoirs, including oceanic and terrestrial systems. A major focus is on developing a better understanding of terrestrial and oceanic primary productivity and the fluxes of carbon within these ecosystems and between them and their biotic environment.

The Atmospheric Chemical Processes program is composed of two elements: the upper atmospheric research program (UARP) and the tropospheric chemistry program (TCP). The UARP is a large, comprehensive research program with NASA playing a leadership role as mandated by Congress under the Clean Air Act of 1976 and the FY 1976 NASA Authorization Act. The program aims at expanding our knowledge of the physical, chemical, and meteorological processes that control the concentration and distribution of stratospheric ozone, thereby providing the necessary input for large-scale global models used to predict the future state of stratospheric composition. The TCP is focused on tropospheric chemical change, the natural and anthropogenic processes that cause it, and its effects on global climate and on the chemistry of the stratosphere through troposphere-stratosphere exchange.

One of the primary challenges in the study of the Earth as a system is understanding the extent and causes of atmospheric chemical changes and their consequences, including stratospheric ozone depletion and potential global climate change.

The Solid Earth Science program conducts research in the fields of geology and geodynamics with the goal of improving our understanding of the evolution, structure, and dynamics of the Earth's interior and surface by testing hypotheses through a vigorous program of measurement and analysis of space-based geodetic, remote sensing, space-based geopotential, field, laboratory, and related data. In geodynamics, emphasis is placed on understanding the rates and mechanisms of the Earth's crustal deformation from local to global scale and how these reflect historical global change or influence current processes of global change. In geology, emphasis is placed on the interaction of the solid Earth with the hydrosphere, atmosphere, and biosphere in programs which address landscape/topographic development and change, volcano-climate interactions, and coastal processes. Natural disaster reduction research includes research on processes of natural hazard occurrence and recurrence, pre- and post-hazard monitoring including measurement of topography and small changes in topography using new/improved remote sensing and geodetic techniques.

The objective of the Laser Research program is to measure the movement and deformation of the tectonic plates of the Earth as well as provide precise orbital tracking of operational satellite systems (i.e., TOPEX, ERS-1). Laser ranging to satellites and the moon, microwave interferometry using astronomical radio sources and transmissions from the Global Positioning Satellite (GPS) system are used to determine precise position locations.

BASIS OF FY 1995 ESTIMATE

The FY 1995 funding is required in the area of radiation and dynamics research to continue studies of the processes associated with cloud-radiation feedback, the water cycle, polar ice sheets changes, the ocean circulation, and heat flux. Research and analysis studies will continue, focusing on forest ecosystem dynamics, marine primary productivity, regional trace gas fluxes, and the biophysics of remote sensing. Analysis of the Topical Oceans Global Atmosphere (TOGA) Coupled Atmosphere Ocean Response Experiment (COARE) data will continue to capitalize on the superb data set obtained by ships, aircraft, buoys, balloon sounders, and island based instrumentation during 1992-1993 in the southwest Pacific Ocean warm pool region. These data are expected to provide unprecedented insights into air-sea exchange and precipitation processes that control the El Niño-Southern Oscillation (ENSO) phenomenon which has global climate repercussions. Further development of plans and preparations for the GEWEX Continental Scale Experiment will also be advanced.

The survey of the Greenland ice sheet by airborne laser altimetry will be continued, with the objective of measuring ice thickening and thinning rates and the associated impact on global sea level. Analysis of the Boreal Ecosystems-Atmospheric Study (BOREAS) experiment data from the major field campaigns will continue. Both of the atmospheric chemical process programs will continue activities to investigate and understand the global atmosphere through laboratory studies and field measurement campaigns in the Antarctic, Arctic and over the Western Pacific. The Solid Earth program will pursue geodynamics research activities in large part through the Fiducial Laboratories for International Natural Science Network. The Geodynamics program will continue definition studies to develop a Gravity and Magnetic Experiment Satellite (GAMES) in partnership with the European Space Agency, and a Satellite de Applicaciones Cientificas-C (SAC-C) satellite with the Argentine Space Agency. Both would involve using gravity radiometry and magnetometers to study at high resolution the variability of Earth's gravity and magnetic fields.

The decrease from FY 1994 to FY 1995 is due to the effects on research and analysis programs of the general downsizing of the NASA budget in addition to reductions to support contractor and the transfer of Small Business Innovative Research to Advanced Concepts and Technology.

BASIS OF FY 1995 FUNDING REQUIREMENT

AIRBORNE SCIENCE AND APPLICATIONS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Airborne science and applications..............	20,707	25,200	26,000

OBJECTIVES AND STATUS

The Airborne Science and Applications program funds the operations of the ER-2, C-130, and DC-8 aircraft to support Earth remote-sensing and atmospheric research. They may serve as testbeds for newly-developed instrumentation and allow demonstration of new sensor techniques before their flight on satellites or on Shuttle/Spacelab missions. Data obtained from these aircraft are used to refine analytical algorithms, and to develop ground data handling techniques. For example, the ER-2 acquires stratospheric air samples and conducts in-situ measurements at altitude ranges above the capability of more conventional aircraft and below those of orbiting satellites. This capability is important in gaining an understanding of stratospheric transport mechanisms. The DC-8 carries a wide variety of instruments, ranging from a large complement of atmospheric sensors, Light Direction and Ranging (LIDAR), and a three-frequency synthetic aperture radar used in surface process studies. The program is also responsible for all maintenance, system upgrades and spares for the aircraft, support personnel and flight hours. The aircraft are often requested by Federal agencies to support national emergencies (i.e., support to Federal Emergency Management Agency during Mississippi River flooding and support to U.S. Forest Service and State agencies in southern California fires).

BASIS OF FY 1995 ESTIMATE

The Airborne Science and Applications program provides a variety of platforms in support of studies of the biosphere, troposphere, and stratosphere. Platforms include a modified C-130, a long-range DC-8 that has been uniquely modified to accommodate a wide variety of specialized instrumentation for atmospheric and Earth surface remote sensing studies, and high-altitude ER-2s, a unique national resource. Several major campaigns are in the planning stages, including a major deployment to Brazil and to the South Pacific. In FY 1995 we will be concluding the ER-2 deployment to New Zealand for Antarctic Ozone, a Congressionally mandated program. The ozone flights are flown from Christchurch, New Zealand.

An ER-2 will also be used for a large number of LIDAR Atmospheric Sensing Experiment (LASE) instrument tests. The majority of these science flights are related to Earth Observing System (EOS) investigations - contributing to algorithm development for the EOS precursor instruments, and supporting individual

university principal investigator research studies. The NASA airborne platforms also support other Federal agencies in support of their specific global research.

C-3.

BASIS OF FY 1995 FUNDING REQUIREMENT

MISSION TO PLANET EARTH INFORMATION SYSTEMS

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Mission to planet earth information systems.....	11,200	11,184	9,800

OBJECTIVES AND STATUS

The Mission to Planet Earth Information Systems program provides scientific computing infrastructure in support of the Mission to Planet Earth research mission. Particular emphasis is placed on providing a balanced system of supercomputers, mass storage, mainframes, workstations and appropriate network connectivity between researchers and components of this system. Currently, this support is provided through the NASA Center for Computational Science (NCCS) at the Goddard Space Flight Center (GSFC) and the supercomputing project at the Jet Propulsion Laboratory (JPL). Both facilities continue to upgrade capacity to keep pace with growing requirements. The supercomputing platform at the NCCS was upgraded, effectively doubling the computational capacity. A corresponding upgrade in mass storage is being evaluated. Installation of a system will occur in the third quarter of the FY 1994.

Another important facet of the program is to monitor and participate in advanced technology programs (such as the High-Performance Computing and Communications (HPCC) program) and to leverage these technology programs to enhance the computational environment for NASA Earth and space science researchers. Specific emphasis has been on early access for Mission to Planet Earth applications to the new parallel supercomputing platforms and collaborative investigation of mass storage technologies.

BASIS OF FY 1995 ESTIMATE

The Mission to Planet Earth information systems program will continue to provide a super-computing environment for science researchers primarily through facilities housed at GSFC and JPL. It will continue to make enhancements to these facilities and will continue to leverage technology programs such as the HPCC.

The decrease from FY 1994 to FY 1995 is due to the effects on research and analysis programs of the general downsizing of the NASA budget in addition to the transfer of Small Business Innovative Research to Advanced Concepts and Technology.

BASIS OF FY 1995 FUNDING REQUIREMENT

EARTH SYSTEMS SCIENCE BUILDING

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995	Page Number
Earth systems science building..................	--	12,000	17,000	CF 2-1

OBJECTIVES AND STATUS

The Earth Systems Science Building (ESSB) will be located at the Goddard Space Flight Center (GSFC) and will house civil service, contractor, and visiting science personnel conducting global change and Earth science research using the Earth Observing System. The FY 1995 funding is the second increment, following the initiation of the project in the FY 1994 Construction of Facilities appropriation. A third funding increment is required in FY 1996 to complete the facility.

The complete description of the ESSB construction is in the Mission Support section of the FY 1995 budget justification.

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1995 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995	Page Number
Aeronautical research and technology............	769,362	1,082,200	898,500	SAT 4-2
Transatmospheric research and technology........	--	20,000	--	SA 4-39
Total....................................	769,362	1,102,200	898,500	

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1995 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS

AERONAUTICAL RESEARCH AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1993	FY 1994	FY 1995	Page Number
		(Thousands of dollars)		
Research and technology base	451,547	418,300	342,800	SAT 4-5
Systems technology programs	265,215	451,900	533,700	SAT 4-16
Construction of facilities	52,600	212,000	22,000	SAT 4-36
Subtotal	769,362	1,082,200	898,500	
Transatmospheric research and technology	--	20,000	--	SAT 4-39
Total	769,362	1,102,200	898,500	

Distribution of Program Amount By Installation

	FY 1993	FY 1994	FY 1995
Johnson Space Center	--	400	--
Marshall Space Flight Center	--	500	--
Langley Research Center	230,688	381,900	337,200
Lewis Research Center	199,932	262,400	251,700
Ames Research Center	293,425	304,300	260,700
Goddard Space Flight Center	6,421	19,300	17,600
Jet Propulsion Laboratory	3,753	4,800	6,000
Headquarters	35,143	128,600	25,300
Total	769,362	1,102,200	898,500

OBJECTIVES AND JUSTIFICATION

The goal of the NASA Aeronautics program is to provide the Nation with leadership in high-payoff, critical technologies, and to assure the effective transfer of research and technology products to industry, the Department of Defense (DoD), and the Federal Aviation Administration (FAA) for application to safe, superior, and environmentally-responsible U.S. civil and military aircraft, and for a safe and efficient National Aviation System. NASA carries out its aeronautics mission in close partnership with the DoD, FAA, U.S. industry, and academia. The FY 1995 estimate reflects the continued need to address critical technology and performance barriers and to strengthen technology development in selected high-payoff areas vital to our long-term leadership in aviation. NASA's Aeronautics program is focused around six strategic goals: (1) develop high-payoff technologies for a new generation of environmentally-compatible, economic U.S. subsonic aircraft and a safe, highly productive global air transportation system; (2) ready the technology base for an economically viable and environmentally friendly high-speed civil transport; (3) ready the technology options for new capabilities in high performance aircraft; (4) develop and demonstrate hypersonic technologies for airbreathing, single-stage-to-orbit flight; (5) develop advanced concepts, physical understanding, and theoretical, experimental, and computational tools to enable advanced aerospace systems; and (6) develop, maintain, and operate critical national facilities for aeronautical research and for support of industry, FAA, DoD, and other NASA programs. In accomplishing these goals, NASA will emphasize customer involvement, the productive and cost-effective provision of products and services, timely transfer of technology to domestic customers, strong university involvement, and the inclusion of minorities and disadvantaged businesses in the conduct of its programs.

BASIS OF FY 1995 ESTIMATE

The FY 1995 Research and Technology program is committed to providing a broad foundation of advanced technology to strengthen the Unites States leadership in aviation, an industry which plays a vital role in the economic strength, transportation infrastructure, and national defense of the United States. Today, we as a Nation are being challenged by foreign competition, by an increasingly strained national airspace system, and by uncertainties about the future of the defense sector of the industry. Because of the importance of aeronautics to the country, and the many ways in which NASA's unique research capabilities contribute to strengthening American aviation, the Aeronautics program is making the new technology investments required to pursue the high-leverage technologies required to support both the subsonic and high-speed civil transport economic viability. These investments are essential to the technology to ensure

U.S. leadership for future competition of a high-speed civil transport and to address the important competitiveness and capacity issues associated with future subsonic transport aircraft.

In FY 1995, the planned budget growth of the focused Aeronautical Systems Technology programs in high-speed research and advanced subsonic technology is maintained and the growth in the high performance computing and communication program is continued. The research and technology base is significantly reduced consistent with overall Agency priorities; these reductions are reflected by reducing or eliminating lower priority activities, closing facilities, becoming more efficient in operations, and lowering the level of technical services support to research activities. One example of how we intend to reduce expenditures while still meeting program requirements is the creation of a consolidated supercomputer facility, to become operational in FY 1995.

BASIS OF FY 1995 FUNDING REQUIREMENT

RESEARCH AND TECHNOLOGY BASE

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Aerodynamics research and technology	160,572	151,000	113,300
Propulsion and power research and technology	102,982	89,400	75,300
Materials and structures research and technology	47,496	48,100	39,600
Controls, guidance and human factors research and technology	65,800	58,800	48,800
Flight systems research and technology	63,840	55,800	47,200
Systems analysis	10,857	10,200	8,600
Rotorcraft industry technology	--	5,000	10,000
Total	451,547	418,300	342,800

OBJECTIVES AND STATUS

The overall objective of the Research and Technology Base program is to provide a strong fundamental foundation for future aviation advances. The major emphasis is on the fundamental understanding of a broad range of physical phenomena, development of computational methods to analyze and predict physical phenomena, and experimental validation of key analytical capabilities. In addition, advanced aeronautical concepts are developed, evaluated for potential benefits and experimentally verified for feasibility. These efforts provide the enabling technology that ultimately leads to future focused technology programs and advanced systems development by U.S. industry.

The majority of the research is captured in the principal aeronautics disciplines of aerodynamics, propulsion, materials, structures, controls and guidance, human factors, and flight systems. A significant portion of the base program is performed in cooperative agreements with the aerospace industry and other Government agencies to facilitate rapid technology transfer. The Research and Technology base also provides the resources required to maintain the aeronautics flight research capability as an important complement to the ground-based experimental and computational facilities. Emphasis in multidisciplinary research, the combining of two or more disciplines in a single activity, has been increased because of the potential improvements in aircraft systems that may be realized with integrated design approaches. Advanced concepts

development and validation provides the basis for verification of multidisciplinary analysis methods. The base also maintains the essential research necessary for future advances in high performance aircraft.

Aerodynamics research and technology provides visionary research to develop world-class aerodynamic capabilities that combine wind tunnels, instrumentation, computational analysis, and flight research. The program seeks to provide the technology which, when applied by the U. S. aerospace industry, will enable the development of economical, safe, quiet, globally competitive aircraft for all speed ranges. Further, the program includes the development of multidisciplinary methodologies to enable the U. S. industry to reduce design cycle time and cost in the development of future aircraft. The primary objective of the program is to provide the fundamental viscous aerodynamic expertise and facilities to meet the ongoing and future design requirements of the U. S. industry, the NASA, the DoD, the FAA, and other Government agencies. To that end, the program seeks to define facility effects to improve test results, advance non-intrusive instrumentation to production status for reliability, accuracy, and ease of use, and develop computational, experimental, and flight databases to support validation of methods. FY 1994 research includes development of pressure and temperature sensitive paint measurement systems that are portable for use in multiple wind tunnel facilities. During FY 1994, the development of low noise technologies for rotorcraft and the enhancement of agility and maneuverability of military aircraft are priority goals. An aggressive flight test effort to document the rotor airloads and acoustics of a modern helicopter rotor will be completed to provide the rotorcraft industry with critical data to modernize their design methods. Also in FY 1994, the program is moving toward providing drag data accuracy of all types to 1/2 count (0.05%), developing and validating advanced wing design techniques, providing accurate, efficient, and reliable computational methods for viscous analysis, and developing aerodynamic flow control techniques. During FY 1994, an advanced infrared measurement technique to determine boundary layer transition will be demonstrated. In FY 1994 and beyond, the program will work cooperatively with the U. S. industry to reduce process times for aerodynamic analysis by an order of magnitude while integrating computational methods into multidisciplinary design and analysis processes and reducing the skill level required for the use of these technologies.

The propulsion and power research and technology program provides technology in critical areas that will enable the U. S. aeropropulsion industry to retain its world leadership position. These critical technologies will enable the industry to increase their competitiveness in developing environmentally acceptable, fuel efficient and highly reliable gas turbine engines. Research efforts include developing analytical tools, developing unique concepts, and conducting fundamental and component experiments both in turbomachinery, addressing both the axial and radial type components, and in combustion reducing NOx emissions. The program pioneers the science and technology of viscous internal fluid mechanics and combustion and their interactions with other disciplines for advanced aeronautical application by the U. S. aeropropulsion industry. This program provides the fundamental viscous aeropropulsion expertise and facilities to meet the ongoing and future design requirements of industry, NASA, DoD, FAA, and other Government agencies. During FY 1994, the program will define sensor requirements for aircraft, including fiber optics and high temperature silicon carbide sensors; provide practical predictive capabilities for

unsteady aerodynamics, heat transfer, and aeroelastic effects in propulsion systems; and deliver databases and validated computational fluid dynamics codes with models of relevant flow physics for turbomachinery and combustors. An advanced experimental database has been obtained via testing the large low speed axial compressor. The test data will validate 3-D multistage viscous codes and investigate blade row interaction in a multistage environment.

In FY 1994, the combustion technology focuses on small engine combustors for regional aircraft applications. Additionally, in FY 1994 and beyond, the program will assess advanced and high risk propulsion concepts, demonstrate reduced NOx emission combustors, and evolve a database of exhaust gas constituents for atmospheric environmental assessments on small engines. The program is moving toward an integrated methodology for propulsion/airframe control design, as well as the assessment of supersonic through-flow engines for advanced supersonic cruise applications. The program seeks to reduce design cycle process times for propulsion system analysis, design, and testing technology and to improve design quality while developing innovative flow control concepts for improved propulsion system efficiency, operations, and performance.

The <u>materials and structures research and technology</u> program is developing advanced materials, analysis methods, test methods and structural concepts to enable the design of safe, lightweight airframes and lightweight, durable, fuel-efficient engines. Materials and structures research is focused on understanding fundamental behavior, developing life prediction methodologies and advancing fabrication technology for light metals, composites and high temperature materials. Computational structures technology is concerned with advanced analytical methods, from the micromechanics level through global response of full-scale aircraft, aeroelastic response and control, and structural design and optimization. Under airframe materials research, there are efforts underway to mature the fabrication technology for high strength, low density aluminum-lithium alloys and for polymer-matrix composites utilizing three-dimensional fiber preforms. At the same time, exploration of new chemical formulations in polymer science is expected to lead to greater environmental durability in this class of materials. For engines, the primary objective of materials research is to increase the temperature capability of the materials used in various sections. Structural research is using aeroelastic benchmark models to gather precise data for validating analytical prediction methods. It is also investigating the feasibility and utility of various smart structures concepts. Computational methods research is developing new models for improved fidelity of predictions of combined thermal and mechanical stresses.

In FY 1994, several promising new polymer formulations will be evaluated for high temperature applications. The hot corrosion resistance properties of single-crystal nickel aluminide, a turbine blade candidate material, will be evaluated. Friction and wear properties of diamond-like carbon film on ceramics will be evaluated. A model of the fast fracture behavior of monolithic ceramic at temperatures up to 1650 degrees Centigrade is being validated against test data. Another model of the combined structural and thermal properties of a ceramic laminate will be developed and tested. Tire friction modeling for landing gear

analysis will continue. Parametric studies and analyses of the behavior of composite shells in buckling will be completed. Open-loop tests of an active control benchmark model will be conducted in the Transonic Dynamics Tunnel, and a rig test of a PMR-II (Polymerization of Monomer Reactants) spinner cone is to be completed. Low-noise concepts of three-bladed and four-bladed rotors on a tiltrotor configuration will be tested in the Langley Research Center 14x22 tunnel. Wing subcomponent concepts are to be evaluated for civil tiltrotor wing applications.

The controls, guidance, and human factors research and technology program works with the U.S. aeronautics industry, the FAA, and its academic partners to pioneer, develop, evaluate, and demonstrate innovative advances in these technologies. The program emphasizes research that will produce aircraft design cost reductions and advances in science, engineering, operational productivity, and competitiveness. The program provides a technology base which supports future aircraft designs for safer and more efficient operations, greatly expands flight envelopes, and increases National Airspace System (NAS) capacity. This technology base includes such technical approaches as requirements studies, mathematical and descriptive models, algorithms development, laboratory studies, simulations, and flight demonstrations. Discussed below are a number of technology products that have reached maturity and will be validated in flight and in operational field tests in FY 1994.

Operational tests of air traffic control automation at the Denver Stapleton Airport should provide evaluation of time-managed aircraft approach. The final phase of this testing is underway at the Dallas-Ft. Worth Airport. Control systems research has scheduled wind tunnel tests to provide systematic characterization of modeling uncertainties in control systems for aeroelastic aircraft. The aircraft atmospheric hazards program is scheduled to complete a rigorous scientific analysis of scattering mechanisms inherent to microwave and laser illumination of aircraft wake vortices. The Rotorcraft Aircrew Systems Concepts Airborne Laboratory (RASCAL) UH-60 aircraft received a major flight control system modification; and flight tests are underway to evaluate color helmet mounted display and low-noise approach profiles for the UH-60. A civil tiltrotor simulation on the Vertical Motion Simulator (VMS) is studying missed approaches, cockpit display requirements, and preliminary engine concepts to enhance one engine inoperative contingency power. Data bases and models of human cognitive and sensory processes and their limitations are included in FY 1994 research activities on human performance. Flight evaluation of an advanced flight management system interface is scheduled to be completed. This system is data linked to air traffic controller automation aids. Researchers plan a real-time demonstration of a method to predict aircraft crews' level of situation awareness. A new flight simulator of the B747-400 glass cockpit was installed in FY 1993 and acceptance tests are underway. Full mission simulation and empirical evaluation of three-dimensional auditory cockpit displays for localization of traffic are complete. In FY 1994, verification of new mathematical methods to assess software reliability are to be demonstrated. NASA and Boeing are working together to apply an ultra-reliable software reuse method for the B-777 navigation system. Tasks which provide flight crucial system technology in FY 1994 include high fidelity simulation of an enhanced rolling control law using actuated nose strakes for military aircraft. Flight tests are planned to demonstrate new

control laws in the High-Alpha Research Vehicle (HARV) aircraft. Application of propulsion controlled aircraft technology continues with civil aircraft. A direct radiation survey of a Bendix flight control computer is planned to be completed in FY 1994. NASA researchers are teamed with industry to develop radiation codes which can predict electromagnetic performance in composite aircraft.

Flight systems research and technology addresses a broad range of needs supporting aviation safety, air vehicle advanced technology demonstration/validation, flight test methodologies, and facility support. In aviation safety, the icing research tunnel is used to study the performance effects of ice accretion on airfoils and to validate analytic models which predict ice accretion for fixed-wing and rotary-wing aircraft. In FY 1994, a computer code for designing and analyzing thermal ice protection systems will be made available to U.S. industry, a joint NASA/FAA/industry program to address the problem of ice-induced tail plane stalls will be initiated, and a joint NASA/industry program to develop requirements for ice protection for Hybrid Laminar Flow Control (HLFC) systems will be initiated. The high angle-of-attack research program continues to explore maneuverability and agility technology. Wind-tunnel and flight-data-validated prediction methods are enabling aircraft designers to develop advanced control concepts and to design modifications for existing aircraft to enhance maneuver performance. Advanced computational fluid dynamics methods have been used to calculate the flowfield around the full F-18 configuration with excellent correlation to data obtained from the F-18 high angle-of-attack research vehicle HARV. The multi-axis Thrust Vectoring Control System (TVCS) installed on the highly instrumented F-18 HARV has been flown at extreme angle-of-attack with excellent effectiveness demonstrated. Delivery and installation of the HARV mechanical forebody vortex control devices will be completed in FY 1994. HARV flights with an inlet rake are also scheduled in FY 1994. The tactical utility evaluation of the X-31 Enhanced Fighter Maneuverability (EFM) aircraft at high angle-of-attack will be completed in FY 1994 along with evaluation of a helmet-mounted display system with audio cues. Limited in-house personnel and test facility support are being provided to support DoD and industry Short Take-Off and Vertical Landing (STOVL) efforts in FY 1994. The F-15 integrated propulsion and aircraft controls technology program has satisfied the original objective of developing real-time optimization of aircraft and engine performance for non-thrust vectoring aircraft at subsonic and supersonic flight conditions and the test aircraft has been retired. The program objective has been extended to include multi-axis engine thrust vectoring with emphasis on supersonic cruise optimization. A new F-15 aircraft testbed (formerly the USAF F-15 Short Take-Off and Landing (STOL) and Maneuver Test Demonstrator) has been acquired and will be modified with axisymmetric thrust vectoring engine nozzles and an enhanced-capability on-board computer in FY 1994. The SR-71 testbed program provides a unique national resource featuring Mach 3+ speeds, 80,000+ ft. altitude, and excellent payload carrying capability to support aeronautics and space science. Several flights benefiting high-speed research and science will be conducted in FY 1994 using the SR-71 aircraft. The highly instrumented F-18 Systems Research Aircraft (SRA) testbed features fiber optic and digital data busses. The F-18 SRA program was established to enable affordable, in-flight demonstration of new aeronautics subsystem technologies to satisfy Government and industry needs. In FY 1994, a flush air data concept along with a high capability airborne research test computer system and various fiber optic and electrical hardware will be evaluated. An F-15B aircraft has

been acquired to replace the F-104 aerodynamics testbed and flight test fixture. The F-15B with advanced flight test fixture will be fully instrumented in FY 1994. The instrumentation and test techniques program and the university research program are continuing activities that promote the development of sensor technology/concepts, new or improved flight research methods, and aeronautics innovations.

The aeronautics systems analysis program conducts long-term technology assessments, identifies technology applications, and performs sensitivity analyses and tradeoff studies from which effective research and technology programs can be developed to meet future civil and military aircraft requirements. Studies conducted under the systems analysis program focus on defining high-leverage, long-range research and technology needs for specific vehicle classes. In addition, the element includes development of advanced analytical techniques, and of design and optimization capabilities. Current efforts include conceptual design studies and environmental impact analyses for subsonic and supersonic transport aircraft and propulsion systems beyond the Advanced Subsonic Technology and High-Speed Research programs. In FY 1994, a study of configurations and mission alternatives for an oblique all-wing aircraft will be completed, and an aero/structural model of this concept will be assembled for detailed studies. System studies of laminar flow systems for supersonic transports and for business jets are to be completed. In the subsonic regime, a study of the infrastructure of the cargo transportation business will be initiated. The concept of an 800-passenger subsonic transport airplane is to be evaluated with engine alternatives. A projection will be made of the technology needs of large propulsion systems in the year 2005. Phase II of the civil tiltrotor cost-benefit/risk assessment study will be completed. A prototype designer's associate (expert system for facilitating design) for propulsion nozzles is to be assembled and demonstrated. Synthesis and analysis capabilities will be upgraded with automated loads and deflections mapping, a variable complexity design system including takeoff and landing analyses, combined aero/structures/performance optimization, and a computer-aided engineering system to support comprehensive geometry modeling. Restructuring engine cycle and flowpath codes in an object oriented framework will begin after review by a government/industry working group. The aeronautics advanced design program is in the second year of a three-year cycle of supporting senior design courses at twelve universities.

The goal of the Rotorcraft Industry TEchnology (RITE) program is to provide an organizational framework to allow NASA and other federal agencies, U.S. industry, and academia to interact in the identification and development of technologies to address technology issues confronting the U.S. rotorcraft industry. In 1994, $5.0 million was allocated to initiate this program. These funds were realigned from aerodynamics research and technology ($2.0 million) and the hypersonic research and technology ($3.0 million) programs. Two institutes will manage the research programs undertaken within RITE and interface with the companies performing the research tasks. The significant characteristics of this effort are the equal cost sharing by industry, the degree to which industry is involved in the identification of the tasks to be undertaken, and the sharing of all information developed within the program by the participants. The five areas identified to date are critical technologies for improved competitiveness, passenger/environmental acceptance, product/process development, aviation infrastructure, and merging of military and civil specifications.

BASIS OF FY 1995 ESTIMATE

For FY 1995, the 18% reduction in the research and technology (R&T) base results from reductions ($47.5 million) to facilities and operations support and technical services along with reductions in the R&T base research activities; not continuing the one-time adjustment for aeronautics facility research and development included in FY 1994 into FY 1995 ($19.0 million); and consolidation of the Small Business Innovative Research activities ($9.0 million) into the Advanced Concepts and Technology budget. Facilities and operations support of research activities have been reduced by closing selected facilities, reducing test shifts, eliminating one chase aircraft, and reducing telecommunications services. Further, technical services, such as data communications, graphics, technical library services, supercomputing capability and aircraft support, have also been reduced. Every effort will be made to minimize the programmatic impacts of these reductions. The resultant FY 1995 research program, although smaller than FY 1994, remains extremely challenging and is described in greater detail below.

Aerodynamics research and technology funding will be reduced 25%. (The aerodynamics reduction includes the $19.0 million one-time facilities adjustment in FY 1994, hence the aerodynamics reductions is actually $18.7 million rather than $37.7 million). The reduction is comprised of operations support for wind tunnels and computational capability plus a $0.7 million reduction in advanced configurations such as oblique wing for high-speed applications. Despite the reduction, the program will continue its focus on customer interaction as its primary objective. This will help the evolving process to determine the next generation of problems to be solved and the development of technology opportunities that will lead to the next generation of NASA systems technology programs. In FY 1995, these facilities are scheduled to be placed on standby (no tests, minimal maintenance): 7x10 high-speed tunnel (Langley Research Center (LaRC)), 8-foot transonic pressure tunnel (LaRC), and possibly (decision not yet made), the 30x60 full scale tunnel (LaRC). Customers have identified a need for, and the program will develop in-flight instrumentation including advanced sensor, data handling, and test techniques for applications ranging from subsonic to supersonic. This program will develop a real-time off-site hook-up to wind tunnel facilities so that customers can observe data operations during wind tunnel testing without being on-site. Standard interfaces will be developed between NASA and industry design processes which will enable faster technology transfer. Recognizing that the design process is migrating to multidisciplinary for efficiency, the program will choose and implement non-aerodynamic disciplines with aerodynamics into the multidisciplinary process. In subsonics, flight research will shift from 737 research to 757, and a semi-span high-lift research capability will be developed for the National Transonic Facility. Flight evaluations of rotor state measurement and estimation concepts will be completed on the Rotorcraft Aircrew Systems Concept Airborne Laboratory (RASCAL) aircraft. In acoustics, 3-D non-intrusive acoustic survey instrumentation will be developed for wind tunnels, and noise prediction will shift to chaotic and turbulent flow first principles. The program will support the Air Force's tail-less fighter program. For supersonic transport development, the program will research concepts to reduce the wing span of these configurations, while determining the effectiveness of conventional control surfaces and evaluating new ones. Advanced transition prediction techniques will enable the development of laminar flow

control system design for applications ranging from subsonic to supersonic, and newly developed Reynolds stress turbulence models will be adapted to industrial computational codes with the goal of computational affordability.

Propulsion and power research and technology funding will be reduced 16%. This includes a $9.8 million reduction of the operations support for propulsion facilities and computational capability plus a $2.1 million reduction that eliminates the supersonic throughflow concept for high-speed applications and a $2.2 million reduction in advanced component structures technology for subsonic transport propulsion applications. The program will continue to emphasize customer interaction in order to determine the next generation of propulsion problems to be solved and the development of technology opportunities that will lead to advanced propulsion systems technology programs. In FY 1995, the Lewis Research Center is scheduled to place the Powered Lift Facility on standby. As the aeropropulsion industry develops strategies for future propulsion systems and further defines their technology needs, the research efforts in this program will evolve to meet those needs. Lower cost, smarter, more reliable propulsion sensors will be developed during FY 1995 that take advantage of advances in micromachining, microfabricating, and integrating optics technologies. In FY 1995, this program will advance engine efficiency through research in cooling effectiveness and emissions controls. Also in FY 1995, real-time displays of multiparameter measurements for engine systems will be developed in the non-intrusive measurement program using advances in lasers, electro-optic devices, neural networks, and data acquisitions. Advances made in FY 1995 in controls research using intelligent and integrated control systems will improve propulsion system reliability and safety. The FY 1995 research in multidisciplinary technology will provide faster and cheaper design and analysis tools for the propulsion industry. This research will integrate computational fluid dynamics, controls, and structures.

Materials and structures research and technology funding will be reduced 18%. This $8.5 million reduction will limit the resources available for computational programs and require additional time for completion of planned experimental research such as the structural testing of an energy-absorbing subfloor concept and the loads calibration of a full-scale wing structure. An experimental evaluation of an energy-absorbing floor substructure concept will be conducted in the Impact Dynamics Research Facility. Instrumentation of a full-scale airframe will be initiated in an investigation of flight loads calibration technology. Multidisciplinary analysis including a complete-aircraft aeroelastic capability based on Euler and Navier-Stokes aerodynamics and finite element structures representations will be demonstrated. Composite shell experiments will be completed, and the data compared with analysis. Analyses will be performed, using finite element methods, of crack interaction geometries in composite materials. Also, a higher order composite element for improved modeling fidelity will be demonstrated. Fatigue damage accumulation models for metal- and intermetallic-matrix composites will be validated. Viscoplastic models for complex structural alloys will be completed. A turbine blade design optimization method using networked distributed computing for a projected 50% reduction in design cycle time will be demonstrated. Work will continue on tire friction modeling, and compilation of a national radial tire database will be completed. Fabrication

technologies will be transferred to industry, including reaction forming of monolithic silicon carbide and casting of specific ceramic composites. The results of the three- and four-blade rotor aeroacoustic testing in the LaRC 14x22 tunnel will be assessed, and a low-noise concept selected. Baseline testing of a tiltrotor aeroacoustic model will also begin, and a rotor blade design simultaneously optimized for aerodynamics, structures, and acoustics will be tested in the Langley Transonic Dynamics Tunnel.

The controls, guidance, and human factors research and technology program funding will be reduced 17% but will continue to emphasize cost-effective and high-payoff technology. This \$10.0 million reduction is comprised of a \$6.5 million reduction to the operations support for simulation facilities and computational capability plus a \$0.5 million reduction that eliminates research in synthetic vision and advanced control algorithms for high-speed applications and a \$3.0 million reduction in aircraft/Air Traffic Control integration research for flight deck automation. In FY 1995, multidisciplinary evaluations of the Descent Advisor air traffic control aid (including automated aids) will be initiated. Flight evaluation at Dallas-Ft. Worth airport of the Final Approach Spacing tool (air traffic control aid) also will begin. The fifth civil tiltrotor simulation on the Vertical Motion Simulator (VMS) will be completed in a joint effort with the FAA. A full-scale test of tiltrotor advanced technology blades will be completed in the 80x120 wind tunnel test section at the Ames Research Center to evaluate noise and performance in support of the short-haul civil tiltrotor program. Wake vortex hazard criteria, as well as the metric-based on-board sensor to detect such hazards, will be developed. Tests in the VMS of civil tiltrotor operations in an urban terminal area will be completed. In FY 1995, the feasibility of carrier phase-based use of the global positioning system (GPS) to support high precision approach and landing will be demonstrated. Human factors technology tests and analyses will be completed that explore advanced visual enhancement aids for ground operations under low-low visibility conditions. Standards for in-flight bunks for crew rest will be validated. Increased emphasis will be placed on multidisciplinary approaches to investigate the integration of aircraft equipped with advanced technologies, such as synthetic vision, data link and GPS, into the National Airspace System. Research will continue to test new methods to provide productive "verification and validation" measures of new flight system software. Flight crucial research will initiate high angle-of-attack flight tests of an F-18 thrust vectoring system which incorporates third control law design. Flight tests of actuated nose strakes will be completed. Emphasis will continue to be placed on the development and validation of design and assessment tools which support cost-effective certification of highly reliable electro-optical flight systems and on methods for automated development of reliable software for such systems. Antenna research will integrate prior year information in order to define standardization and machine utilities for electromagnetic antenna codes.

In flight systems research and technology, funding will be reduced 15%. This \$8.6 million budget reduction will be accommodated by infrastructure reductions at the Dryden Flight Research Facility, descoping the F-18 High Alpha Research (HARV), extending into FY 1995 the schedule for the F-15 based integrated propulsion/flight control research program, and reducing testbed aircraft program activities. The program will concentrate its funding in the technology areas discussed below. The aviation safety program will

concentrate on testing a thermal anti-icing concept for hybrid laminar flow control configurations and performance testing of an advanced three-dimensional high-lift wing model in icing conditions. The high angle-of-attack research program will focus on evaluation of mechanical strakes for forebody vortex control separately and in combination with engine thrust vectoring in the F-18 HARV. Limited in-house personnel and test facility support will be provided to continue to support DoD and industry STOVL efforts in FY 1995. The F-15 aircraft testbed with axisymmetric thrust vectoring engine nozzles and enhanced-capability computer will be used to demonstrate optimized flight performance. An SR-71 flight experiment to determine the effects of wing platform variation on sonic boom signature and to validate sonic boom analytic models is planned. Flight operation of the F-18 SRA testbed aircraft will continue to support development of advanced fiber optic flight control systems in FY 1995. The F-15B aerodynamic testbed and advanced flight test fixture will be used to conduct one or more basic aerodynamic phenomena flight experiments. The instrumentation and test technique program and the university research program will continue in FY 1995.

The aeronautics <u>systems analysis</u> program funding will be reduced 16%. This $1.6 million reduction will result in a lower level of operations support for computational capability along with a reduction to the planned investigations of advanced configurations for high-speed and subsonic transport applications. This program will continue the development of analytical methods and multidisciplinary design methods within its budgetary constraints. It will continue multidisciplinary aircraft synthesis capability enhancements through the Aircraft Synthesis Institute. The program will complete restructuring engine cycle and flowpath codes in object oriented language and will decide on the direction for further development. It will complete and evaluate a prototype of an expert system for facilitating the procedure of airframe design (a designer's associate for airframes). Senior level classes at twelve U.S. universities will conduct advanced aircraft design projects utilizing mentors at NASA research centers. Supersonic transport studies will include the continuing investigation of alternative configurations and a study of the economics of long range supersonic air service. A systems study of innovative large aircraft will be completed. A market sensitivity study for civil tiltrotors incorporating advanced technologies will be conducted, and the technology needs for small propulsion systems in 2005 will be estimated. The aero/mechanical design for a Mach 2+ supersonic through-flow fan concept will be completed.

Within the <u>Rotorcraft Industry TEchnology</u> (RITE) program, projects to be initiated in FY 1995 include the development of health and utilization systems for increased power train reliability and safety, the development of technology for advanced transmissions for longer maintenance intervals and more reliable operation, noise and vibration reduction for increased customer acceptance, and low cost avionics and flight control for all weather operation. This effort represents an unique and new way for NASA to interact with its' customers. Because of the departure from traditional program characteristics, an independent review will be undertaken at the end of five years to determine the success of the program in developing and transferring useful technology to the users, and their ability to incorporate that technology into improved products. The results of that review will determine whether the program is continued or eliminated.

Within the research and technology program, hypersonic research and technology will be restructured and transferred into the hypersonic technology program portion of the system technology programs beginning in FY 1995.

BASIS OF FY 1995 FUNDING REQUIREMENT

SYSTEMS TECHNOLOGY PROGRAMS

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
High-performance computing and communications	30,359	65,600	76,100
Materials and structures systems technology	24,388	25,700	24,300
Numerical aerodynamic simulation	47,930	48,100	46,200
High-speed research	116,995	197,200	221,300
Advanced subsonic technology	12,425	89,300	125,800
Hypersonic technology program	33,118	26,000	40,000
Total	265,215	451,900	533,700

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
High-performance computing and communications...	30,359	65,600	76,100

OBJECTIVES AND STATUS

The high-performance computing and communications (HPCC) program is a multi-agency endeavor which involves NASA, the Department of Energy, the National Science Foundation, the Department of Defense (DoD), the Department of Commerce, the National Institutes of Health, the Environmental Protection Agency, and the Department of Education.

NASA's involvement in the HPCC program will accelerate the development and application of high-performance computing technologies to solve the Agency's grand challenge research problems. The NASA HPCC program is focused to enable broad advances in aerospace vehicle design, Earth and space systems science research, access to databases of remote sensing images and K-12 science education.

NASA's primary role in the Federal program is leading the development of applications software and algorithms suitable for massively parallel computing systems which will increase system performance to the sustained teraFLOPS (10^{12} floating point operations per second) level. NASA's other roles include evaluating experimental hardware for testbeds, supporting the development of the National Research and Education Network (NREN), promoting long-term research of the underlying theory and concepts of high-performance computing and increasing the pool of personnel trained to use HPCC technology, developing digital library technologies and networking technologies to improve the public access to remote sensing data, and leading in the development of Earth and space science curriculum material for K-12 science and math education.

NASA is the lead agency for coordinating plans to develop systems software and tools for the Federal HPCC program. In May 1993, a workshop of experts from industry, academia, and government was convened to produce a national agenda for software and tools for high-performance computing applications. A technical report summarizing the workshop findings was published; this report will be used to help formulate a national perspective on systems software requirements. NASA also is leading Federal efforts to make HPCC software less expensive and more robust by encouraging software sharing and reuse. NASA has established an experimental software exchange system that connects software repositories across a number of Federal agencies. A series of metrics have been developed to compare alternate architectures for future generations of the exchange systems.

Significant progress has been made in the program including: installation of a second generation testbed of 50×10^9 FLoating OPerations per Second (GigaFLOPS), awarding grants to multidisciplinary research teams to support the Earth and Space Sciences (ESS) project, and contributing to, and continuing to act as a member of the Concurrent Supercomputing Consortium for the use of Intel Corporation's massively parallel Paragon supercomputer installed at the California Institute of Technology. Specific accomplishments include: generating 3-dimensional images of the planet Venus from Magellan satellite data; direct numerical simulation of large, time-dependent compressible Navier-Stokes equations; and three-dimensional compressible turbulence simulations for high-Reynolds numbers.

Single discipline computational fluid dynamics (CFD) codes were adapted for a number of massively parallel supercomputers including the Thinking Machines CM5 and Intel Paragon. These pilot fluid codes are being applied to both high-speed civil transport and high-performance aircraft applications. NASA also accomplished the benchmarking of multidisciplinary codes on parallel supercomputers, including the development and demonstration of a coupled aerodynamics and structures code on the Intel Paragon supercomputer. Furthermore, NASA researchers have created methods for streamlining the process required for developing an optimal airframe design. The development of these codes complements the High-Speed Civil Transport (HSCT) program by allowing aircraft manufacturers to analyze different design options rapidly and produce vehicles more efficiently with optimal performance and reduced design cycle costs.

NASA researchers also have established a parallel computing testbed using a cluster of high-end IBM workstations. This testbed will provide for the early evaluation of clustered workstations for multidisciplinary aeropropulsion simulation.

NASA also contributed to the advancement of the National Research and Education Network by entering into a cooperative agreement with the Department of Energy to procure research network services based on emerging cell-switching technology that operates at 45 megabits per second (mbps). This is a vast increase over previous network services which only operate at 1.5 mbps. These interconnects are essential to connect NASA Field Centers at greater data exchange rates and provide industrial and university researchers access to NASA computing testbeds.

In addition, NASA made several contributions to the program's basic research and human resources component by funding in-house activities to develop advanced algorithms for multidisciplinary applications on parallel computing testbeds. It provided funding support for university efforts through NASA research institutes and provided funding for seven graduate student researchers. Finally, NASA advanced its outreach efforts for K-12 grade students by selecting two pilot high schools to begin the development of networking-supported research and education activities.

BASIS OF FY 1995 ESTIMATE

In FY 1995, NASA's HPCC program is focused in three major areas: integrated, multidisciplinary computational aerospace vehicle design; multidisciplinary modeling and analysis of Earth and space science phenomena; and development of Information Infrastructure Technology and Applications.

NASA plans to expand activities to broaden the reach of the HPCC program and accelerate the development of a national information infrastructure by supporting research and development in education, digital library technology, and access to Earth and space science data. In education, NASA will increase its focus on developing K-12 education products available over the NREN and establishing teacher training programs for the utilization of NASA education products. To this end, NASA will evaluate initial K-12 digital educational material components and tools relating to TeraFLOPS systems in FY 1995. In digital library technology, NASA will advance technology for petabyte scale data storage systems. NASA also will increase efforts to make Earth and space science data more widely available by developing and evaluating prototype digital data bases of images and software that are available over the NREN.

Grand challenge software applications research will proceed in two distinct projects: the computational aerosciences (CAS) project and the Earth and space sciences (ESS) project. The CAS project will direct its efforts towards continuing the development of multidisciplinary algorithms and advanced software technology in four Grand Challenge areas. These areas are: high-speed civil transport (HSCT), high-performance aircraft, subsonic aircraft, and rotorcraft applications. The ESS project will focus on grand challenge teams selected in FY 1993 in the areas of: climate modeling; studying ocean, land and atmosphere dynamics; modeling magnetosphere-solar wind interactions, stellar interiors and surfaces, star/galaxy creation and evolution, and the formation of other cosmological structures; analyzing enormous geophysical databases; and the assimilation of atmospheric data.

Testbeds are a crucial part of this program because they provide a key tool for interdisciplinary research teams to develop and evaluate applications and systems software and to evaluate scalable hardware architectures and peripherals. A key to successful exploitation of massively parallel computing power will be the blending of application-driven and architecture-driven computer systems and software to most effectively meet NASA's needs. Third generation prototype testbeds of 50 to 100 GigaFLOPS are scheduled to become functional in FY 1996. These testbeds will not be replacements for the numerical aerodynamic simulation (NAS) system or any of NASA's other computational facilities, but rather will serve as proof-of-concept systems which could be used by those computing facilities once the systems are scaled up and ready for operational use. Also, satellite-based gigabit applications using the Advanced Communications Technology Satellite (ACTS) and associated ground terminals will be demonstrated in FY 1995.

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Materials and structures systems technology	24,388	25,700	24,300

OBJECTIVES AND STATUS

The objective of materials and structures systems technology, also known as the advanced composites technology program, is to develop innovative cost-effective structural concepts and fabrication processes to more fully exploit the advantages of composite materials in primary structures of future aircraft. While the current demonstrated level of composites technology can promise improved aircraft performance through reduced structural weight, it does so at an inhibiting increased cost. Further development of the technology is pursued through material formulation and processing refinements, innovative fabrication concepts with their resulting unique structural configurations, and analytical developments for improved structural behavior prediction. The improved technology levels will be demonstrated and validated by fabrication and testing at the subcomponent and subscale component levels. Such validation is an essential building block leading to full-scale primary structures. The program goals are to develop technology that will reduce airframe structure acquisition costs by 25% and structural weight by 30% to 50%, after resizing the aircraft for maximum benefit. To achieve these goals, a new approach to composite design must be developed by integrating the design concepts with advanced fabrication techniques using new material forms. Understanding of failure mechanisms and behavior under complex loading is critical to establishing the data base for innovative design with composites. Components constructed using new structural concepts (advanced fiber placement, woven textile preforms, and resin transfer molding (RTM)/stitched) show potential for achieving cost-effective composite primary aircraft structures.

During FY 1994, development of design and manufacturing techniques for composite fuselage subcomponents and full-scale wing components is continuing with a significant emphasis on verification testing. Validation of the fuselage keel damage tolerance and load redistribution will be completed. Testing of the woven textile fuselage frames and window belts and development of innovative tooling and requirements for a weaving machine will be completed. Testing is continuing on the fuselage side panels to ensure the pressure load is properly distributed about the windows. Testing will begin to assess the load transfer across the major intersection between the fuselage crown and side panels. Completion of benchmark tests during FY 1994 for fuselage panels to verify the analytical methods will allow prediction of the behavior of a full-scale fuselage. A cost model developed under this effort will be exercised to predict the cost and weight of the fuselage. Major milestones in the development of the composite wing will also be reached during FY 1994. These milestones include wing subcomponents design, fabrication, and checkout; and the design of a full-scale semispan composite wing box. Completion of development of RTM/stitching technologies in FY 1994 will enable initiation of fabrication of the wing box. The experimental characterization of the mechanical

properties, damage tolerance, and fatigue response of RTM-type resins and laminate architecture of woven and stitched preforms will be completed. The advanced stitching equipment will be constructed. The fifth technical conference will be held to ensure continued dissemination of the technology to airframe manufacturers and materials suppliers.

BASIS OF FY 1995 ESTIMATE

During FY 1995, development of composite fuselage structure will emphasize completing the fabrication and testing of cost-effective side panels. Global assessment of the integration of the most promising crown, side and keel panel concepts for assembly of a full fuselage barrel section will be completed. Forward keel panels will be tested to validate the capability to redistribute the highly concentrated load at the keel beam attachment joint and to correlate analysis with test results. Detailed design of side panels will be completed and 7 feet by 8 feet manufacturing trial panels will be fabricated and evaluated. Side panels containing multiple cutouts for doors and windows will be tested to validate load redistribution around the cutouts and to verify analysis and tests correlation. Cost models will be exercised to predict cost and weight for the final side panel and splice designs. Development of the composite wing structure will emphasize testing a 12-feet stub box and scale-up of the fabrication technology by building subcomponents for a 40-feet semispan wing box. Braided wing stiffeners will be evaluated. The RTM/stitched materials database will be completed. The analytical model developed to predict flow and cure of RTM/stitched composite structures will be validated. The sixth technical conference will be held to ensure continued dissemination of the technology to airframe manufacturers and materials suppliers. All Phase B activities will be completed at the end of FY 1995.

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Numerical aerodynamic simulation................	47,930	48,100	46,200

OBJECTIVES AND STATUS

The numerical aerodynamic simulation (NAS) program vision is "To provide the Nation's aerospace research and development community by the year 2000 a high-performance, operational computing system capable of simulating an entire aerospace vehicle system within a computing time ranging from one to several hours." The objectives of the NAS program were chosen to meet this vision: (1) act as a pathfinder in advanced, large-scale computational capability through systematic incorporation of state-of-the-art improvements in computer hardware and software technologies; (2) provide a national computational capability, available to NASA, DoD, industry, other government agencies and universities, as a necessary element in ensuring continuing leadership in computational fluid dynamics and related computational aerospace disciplines; and, (3) provide a strong research tool for the Office of Aeronautics. The NAS facility provides the tools and resources dedicated to obtaining solutions to problems which may be intractable on less than state-of-the-art computer systems, including solutions to the Navier-Stokes equations, (enabling performance analysis predictions for complex aircraft geometries). In order to ensure this degree of computational capability, the NAS program continues to implement the following efforts: (1) acquire pathfinding, state-of-the-art, high-speed processors (HSP's); (2) provide a uniform, balanced, user-friendly system with equivalent capabilities for local and remote users; (3) maintain an auxiliary processing center for secure processing; (4) research existing parallel architectures and incorporate them into future generations of the NAS; (5) develop a hardware and software environment for prototyping and testing of computers, networks, storage devices, workstations and graphic output devices; and (6) continue to research and enhance an increasingly sophisticated system of hardware/software tools and environments to assist the user in performing CFD tasks efficiently.

During FY 1994, balanced system software and support for the HSP's is achieved through a continuous upgrade process. The third high-speed processor (HSP-3) was placed in operation in March 1993, with a major upgrade to one gigaword of memory in September 1993, making NAS a unique facility combining high-speed computation with a large memory. HSP-3 is now providing a fourfold increase in computational hours available to the NAS community. Mass storage capacity is 9.6 terabytes, enabling quickly available data storage consistent with HSP output capability. The AERONET is operational. The AERONET is the long-haul communications network which replaced older, switched networking with a newer routed (more reliable and efficient) network and increased traffic throughput speed by up to a factor of 10. The next generation workstations (WKS-III) will be acquired in FY 1994 to provide a threefold improvement in workstation interface capability to the HSP's in FY 1994. To meet the challenge of providing increased operational computing capability for aerospace applications, pathfinding research continues in parallel architectures and algorithms with mapping of

specific aerodynamic simulation problems onto advanced computational platforms. During FY 1994, user interface and visualization software research emphasis is continuing to shift toward multidisciplinary tools and requirements.

BASIS OF FY 1995 ESTIMATE

The number of accounts will be maintained around its current level (about 2000) continuing the diverse use of the system by NASA, the DoD, other Government agencies, industry and academia. During FY 1994, the next generation workstation (WKS-III) will be installed and become operational. The funding reduction from FY 1994 to FY 1995 will delay the planned release date of the request for proposal (RFP) for the fourth high-speed processor (HSP-4) from FY 1994 to FY 1995. The HSP-4 is expected to provide another fourfold increase in capability over HSP-3. Other hardware and software elements of the extended operational configuration will continue to be enhanced as part of the continual process for development of future versions of the NAS.

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
High-speed research..............................	116,995	197,200	221,300

OBJECTIVES AND STATUS

Studies here and abroad have identified a substantial market for a future supersonic airliner -- the high-speed civil transport (HSCT) -- to meet the rapidly growing long-haul market, particularly for the Pacific-rim sector where travel is projected to increase four-fold by the year 2000. Over the period from 2005 to 2015, this market could support an estimated 500 to 1000 HSCT aircraft, thereby creating a multi-billion dollar sales opportunity for its producers. While current technology is insufficient, the studies further indicate that an environmentally compatible and economically competitive HSCT could reach fruition through aggressive technology development and application. NASA's High-Speed Research (HSR) program is providing a public-sector catalyst in addressing this important opportunity with U.S. industry through a two-phase approach. Phase I, a seven year effort which began in FY 1990, is defining critical HSCT environmental compatibility requirements in the areas of atmospheric effects, community noise and sonic boom. It is also establishing a technology foundation to meet these requirements. Phase II of the HSR program, a nine year undertaking started in FY 1993, is directed at developing and verifying, in cooperation with U.S. industry, the high-leverage technologies essential for economic viability in addition to environmental compatibility.

Progress to date has provided growing confidence that the necessary technology can be developed to satisfy the critical environmental concerns. Most importantly, assessments of the potential impact of a future HSCT fleet on stratospheric ozone using the latest two-dimensional atmospheric models (incorporating multi-phase chemistry and more detailed aircraft operational scenarios than previously used), continue to predict very small effects for HSCT's with low-emission combustors. The data base of in-situ observations of heterogeneous chemical processes in the upper atmosphere, which have been shown to be robust in laboratory studies, has also been expanded by the successful FY 1993 Stratospheric Photochemistry, Aerosols and Dynamics Expedition (SPADE). Results from SPADE are being incorporated into continuing atmospheric model development and laboratory studies, and are also serving to assist planning for the Measurements for Assessing the Effects of Stratospheric Aircraft (MAESA) complement to the 1994 Airborne Southern Hemisphere Ozone Experiment (ASHOE) of NASA's Upper Atmosphere Research program. In MAESA, additional atmospheric measurements will be made from the ER-2 aircraft in flights between Moffett Field, California and Christchurch, New Zealand. Related measurements on flights from a Pacific equatorial site are also planned with the new Perseus autonomous aircraft, pending successful completion of the acceptance flight testing now underway at the Dryden Flight Research Facility. These measurements will be used to ensure that the chemistry of the atmospheric models is representative of all seasons and geographic locations, and accurately simulates the interactions of the proposed aircraft emissions and operations. The program's interim assessment and research plans were also submitted to the National Research Council in FY 1993 for

review, and specific recommendations on additional research that can further reduce model uncertainties are currently being incorporated into the research plans to provide the best possible basis for future assessments.

In the pursuit of ultra-low-emission engine technology for future HSCT application, flame tube laboratory tests of advanced combustion concepts have successfully achieved the desired levels of less than five grams of nitrogen oxide per kilogram of fuel burned. During FY 1993, the laboratory tests were extended to higher inlet temperatures with no significant increase in nitrogen oxide production. The application of the knowledge base from these tests to practical combustor configurations also progressed to the fabrication of sector hardware for both the lean, premixed, prevaporized and the rich burn, quick quench, lean burn concepts. During FY 1994, testing of these combustor sectors will be conducted to provide the basis for the selection of the preferred combustor configuration in FY 1996.

In noise reduction, upwards of eighteen decibel noise suppression has been achieved through advanced mixer-ejector nozzles, and wind tunnel testing of innovative high-lift devices shows an additional two to six decibel potential through advanced operational procedures. As a nominal twenty decibel reduction is needed to achieve levels equivalent to the same stringent FAR 36, Stage three noise standards required for today's new subsonic transport aircraft, there is growing confidence that the community's needs can be satisfied. A second generation of model mixer/ejector nozzles was evaluated in coordination with analysis of the primary and backup engine concepts, and the results indicate that acceptable community noise levels and economical performance can be achieved. Acoustic liners for the engine nozzles designed to reduce mixing noise have been evaluated in small-scale tests and are providing the basis for the preliminary design of the best nozzle concepts for the large-scale experiments planned for FY 1999. Similarly, further high-lift concept developments and refinements, including testing at high-Reynolds number conditions in the National Transonic Facility, continue to show payoffs in helping to alleviate aircraft noise exposure to the community.

Aerodynamics technology efforts have also involved testing of the industry's baseline aircraft design in subsonic and transonic wind tunnels. Efforts to provide the ability to soften the sonic boom with minimal penalty in aerodynamic efficiency also continued with scale model wind tunnel testing, and SR-71 flight tests to investigate pressure disturbance propagation through the atmosphere. In FY 1993, supersonic laminar flow control research also progressed with testing of a leading edge wing modification on the F-16XL aircraft, and successful demonstration of the fabrication process for the large suction panel to be tested on the F-16XL in FY 1995.

Development of enabling propulsion materials remains focused on ceramic matrix composites (CMCs) for low-emission combustor liners and intermetallic matrix composites (IMCs) for light-weight, low-noise nozzle components. The commercial viability of selected processes for producing continuous ceramic fibers for CMCs and IMCs was established, and initial test results indicate that these fibers meet the established program goals for physical and mechanical properties, thermal stability, and environmental durability. A joint

government and industry assessment was completed allowing the most promising CMC materials to be selected for further development and evaluation in combustor liner segment tests. Plans have been completed for fabricating larger scale elements of the selected materials, fabrication process feasibility tests were started, and design of the CMC liner segments was initiated. Scale-up of the most promising fiber and fiber coating processes for IMCs was also started, along with development of IMC life prediction codes. A benchmark test facility for conducting high-temperature tests of candidate CMC and IMC panels was installed at the Lewis Research Center to guide further development and evaluation efforts. Trade studies to select potential backup combustor and nozzle materials were conducted and development of these materials is being pursued as part of the program's risk management plan. Development of advanced materials for other critical propulsion system components, such as fan containment structure, compressor and turbine disks, and turbine blades, was also initiated.

Early efforts in airframe materials and structures technology are focusing on long-lead needs for developing and evaluating advanced aluminum and titanium alloys, polymer matrix composites (PMCs), adhesives and sealants. During FY 1994, candidate PMCs will complete one-half of the lifetime testing for thermal aging (with no mechanical loads) at anticipated flight temperatures over long periods. Weight loss measurements at 1/3 lifetime for some of these candidate materials indicates excellent thermal stability. A long-term durability test facility for conducting thermomechanical fatigue (TMF) tests of candidate HSCT materials was installed at the Langley Research Center. Mechanical property tests of several developmental high-temperature aluminum alloys also indicate potential for meeting program goals for strength, fracture toughness, and thermal stability. Initial design integration trade studies to evaluate wing and fuselage materials and structural design concepts were completed, and some of the most promising concepts are being further evaluated through detailed design, fabrication, and testing. Structural concept evaluations for use in supersonic laminar flow control wing structures were also initiated.

Initial flight deck systems research and technology development efforts in FY 1994 will be concentrating on developing the technical requirements for the synthetic vision system, and evaluating advanced displays to assure that an HSCT can safely and efficiently be integrated in the international air transportation system. Modeling of the HSCT aerodynamics, structural modes, flight and propulsion controls, and sensors supporting the synthetic vision system will also begin. Fixed-base simulations using generic computer generated display formats will be a major tool in evaluating flying qualities, flight and propulsion controls, guidance, displays, sensor fusion algorithms, decision aides, structural mode suppression and gust alleviation systems throughout the development program.

System-level integration studies were continued as the primary means to assure that environmental goals can be achieved in concert with economic viability objectives. A key milestone was achieved in October 1993, with the selection of the primary and backup propulsion system configurations from the five most promising candidates based on noise reduction capability assessments, direct operating cost mission studies, as well as overall risk analysis. In FY 1994, a rigorous set of metrics will be developed in cooperation with

industry to measure the integrated progress of all Phase II technology areas to assist in future technology down select decisions.

BASIS OF FY 1995 ESTIMATE

The Phase II portion of the HSR program expands and builds on the technology solutions being developed in Phase I. In combination, they represent the complementary and necessary technologies critical to the U.S. aeronautics industry in order to make informed decisions regarding future HSCT development and production.

In the area of atmospheric effects, a comprehensive assessment will be conducted in FY 1995 as the final related activity of the Phase I HSR program. This assessment will be based on computational models with improved simulations of heterogeneous chemistry and dynamics effects, including incorporation of the results from MAESA, as well as the best possible aircraft operational scenarios projected at that time based on continuing market studies. Development of the unique capabilities offered by unmanned air vehicles as measurement platforms will continue to emphasize improvements in propulsion systems for operation in the rarefied upper atmosphere, and will also include efforts directed at providing increased range, payload and flight duration capability.

Lean, premixed, prevaporized and rich burn, quick quench, lean burn combustor flame tube and sector rig test results will be used to refine the design of the full annular combustor rigs for FY 1997 testing directed at validating the low NOx performance for an operational combustor. These tests will confirm the combustor's capability for stable and efficient operation over the full range of conditions from startup, taxi and takeoff, through climbout, cruise, and landing. In a parallel effort, preliminary design will begin for combustor experiments with a testbed engine planned for FY 1999. Continuing small scale nozzle test results will be used to support the preliminary design of the selected nozzle concept at the end of FY 1995 for future large scale experiments with test-bed engines over a range of operating conditions. Engine inlet technology development will focus on the two-dimensional, bifurcated configuration to advance this concept to the same level of maturity as the axisymmetric concept.

The enabling propulsion materials effort will continue to focus on critical combustor and nozzle materials needs, with emphasis on supporting the major program milestone for preliminary concept selection in FY 1996. Development of combustor and nozzle backup materials and materials for other critical components will also continue, with increasing levels of effort. Fabrication of CMC combustor liner segments will be completed and segment testing will be started. Design and fabrication of CMC combustor liner sectors will also be started. Down-selection of the most promising IMC materials will be conducted and the design of critical nozzle subcomponents will be initiated.

In FY 1995, aerodynamics technology efforts will continue with primary emphasis on completing the wind tunnel evaluation of the industry's baseline aircraft design at subsonic, transonic, and supersonic speeds.

Computational analysis will be used to optimize the total wing-body configuration, including propulsion system integration, to evolve a second generation design for FY 1996 wind tunnel testing. Also in FY 1995, analytical and wind tunnel evaluations of low-boom, high-performance configurations will be conducted and the sonic boom flight research will be completed, thereby allowing an assessment of HSCT flights over the ocean, on approach to coastal regions, and over potential unpopulated areas. In the subsonic speed regime of takeoff, climb-to-cruise, and approach conditions, high-lift concept development will continue with computational and experimental aerodynamic evaluations and noise reduction assessments. The most promising high-lift concepts will be selected in early FY 1996 and then developed for flight testing on an F-16XL aircraft. Active supersonic laminar flow control flight research will begin in FY 1995, with the testing of the large suction panel on a second F-16XL aircraft.

The airframe materials and structures technology development efforts will also emphasize support of the critical preliminary concept program milestone. In FY 1995, the most promising materials and processes will be down-selected and real-time thermomechanical fatigue testing will be initiated by NASA and industry participants. Preliminary design studies of innovative wing and fuselage materials and structural concepts will be completed, and results of the continuing design integration trade studies will be used to select wing and fuselage concepts for subcomponent design, fabrication, and testing. Design and fabrication of a flexible wind tunnel model for aeroelastic response measurements will be completed in FY 1995 for wind tunnel testing in FY 1996. This model is also being designed to provide accurate measurements of unsteady aerodynamic pressures for use in aeroelastic analysis codes, and will provide future testing of active controls concepts for load alleviation.

Flight deck systems research and technology development will complete the definition of the synthetic vision requirements for a forward visibility system and for the next generation flight deck. Various combinations of sensors and anomaly resolution procedures will be developed and evaluated to establish the display system baseline. Pilot evaluation using flight simulators is an important aspect of this element. Both fixed-base and the more sophisticated motion-base simulators will be used, ultimately transitioning to in-flight simulators. A major portion of the FY 1995 flight deck activity is focused on the characterization of the synthetic vision and sensor suite planned for completion in early FY 1996.

Because of the high level of interdependency among the above technologies, system-level integration studies will continue to be conducted in order to assure that environmental goals can be achieved in concert with economic viability.

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Advanced subsonic technology....................	12,425	89,300	125,800

OBJECTIVES AND STATUS

With competition from foreign competitors greatly increasing, technology is critically needed to help preserve the U.S. aeronautics industry market share, jobs, and balance of trade. Exports in large commercial transports make a significant contribution to the U.S. balance of trade. However, according to industry estimates, the U.S. world-wide market share has slipped from a high of 91% during the 1960's to 67% in 1992. Increasing congestion in the aviation system and growing concerns about the environmental compatibility of aircraft may limit the projected growth. According to the Federal Aviation Administration (FAA) 1991-1992 Aviation System Capacity Plan, delays due to weather and the volume of aircraft in the Air Traffic Control System cost U.S. operators more that $4.7 billion per year in excess fuel burn and additional operational costs during 1990. More stringent noise curfews and engine emissions standards are expected before the end of this century. In FY 1994, the advanced subsonic technology (AST) program was augmented with seven new elements to develop focused technologies of high-payoff to enable a safe, highly productive global air transportation system that includes a new generation of environmentally compatible, economical aircraft that are superior to foreign products. The two original elements, fly-by-light/power-by-wire and aging aircraft, are continuing to make excellent progress. The seven new elements include noise reduction, terminal area productivity, integrated wing design, propulsion, short-haul aircraft, technology integration, and environmental impact. In FY 1995, the composites element will be initiated.

The goal of the fly-by-light/power-by-wire element is to provide lightweight, highly reliable, electro-magnetically immune control and power management systems for advanced subsonic civil transport aircraft. In FY 1994, the experimental laboratory for validating analytical methods will be completed. This laboratory provides a means for assessing the effects of high intensity radiated fields on digital electronics aboard advanced aircraft. Laboratory testing of critical optical and power components is being performed. These tests are a means of exposing components, such as electrical actuators and fiber-optic sensors and cables, to actual flight conditions in order to understand the behavior of the components in these environments.

The aging aircraft element is developing advanced technologies that will be used by the aeronautics industry in the U.S. to ensure the continued safe flight of its aging commercial transport fleet. Improved methods that predict the effects of service history and the environment on aircraft durability have been developed and transferred to the airplane manufacturers and the FAA. During FY 1994, efforts are focused on the development and verification of an analytical methodology to predict when small fatigue cracks become so widespread that the residual strength of the fuselage is reduced below a safe level and to establish the requirements for the in-service inspection technology. In cooperation with several U.S. airlines, progress

is also being made in developing and demonstrating advanced, large-area nondestructive inspection methods to reduce cost while maintaining the reliability of the inspection. A new thermal method developed to detect disbonds has the capability to identify corrosion that may be present in these disbonded regions. In-service inspection technology to detect corrosion damage is being developed. Field demonstrations of prototype portable systems will be conducted at airline maintenance facilities and Air Force Air Logistics Stations. Industrial partnerships will continue to be pursued with manufacturers of inspection equipment to develop commercial equipment for use by the airline operators.

With international treaty organizations actively considering more stringent noise standards, the noise reduction element is developing technologies to ensure that new noise standards do not impact the growth of the air transportation system nor the U.S. aircraft industry's competitiveness in the world market. In FY 1994, a key research tool in identifying promising noise reduction technologies, an integrated fan noise model, will be developed and validated. An assessment of airframe noise will identify shortcomings in the current empirically based prediction methods, and will help guide the computational aeroacoustics efforts to fill these shortcomings. Methods for reducing noise levels in aircraft interiors are currently being validated in laboratory tests to help refine their application for future flight demonstrations. Community noise impact models will be expanded to include population density, a first step in developing techniques to analyze the effect of aircraft sound levels in communities at specific airports.

The goal of the terminal area productivity element is to safely increase the air traffic capacity in the terminal area during poor weather to the level that can be managed during good weather. In cooperation with the FAA, the approach is to develop and demonstrate technology and procedures both in the aircraft and on the ground, to safely reduce aircraft spacing in the terminal area, enhance air traffic management and reduce controller workload, improve low-visibility landing and surface operations, and to perform systems analyses to ensure compatible integration of these new aircraft and air traffic systems. Initiated in FY 1994 and leveraging NASA's prior air traffic control efforts, the terminal area productivity element is evaluating the potential for applying digital data communications technology between the ground air traffic controllers and the aircraft to allow for more adaptable aircraft spacing capabilities. In order to allow more adaptable spacing, reduced separation requirements are being investigated by evaluating wake vortex issues and community noise constraints, as well as examining the potential for integrating enhanced aircraft flight management and the air traffic management systems. The replacement for the transport systems research vehicle is being acquired in FY 1994 and installation of an existing simulator and associated computer systems will begin in preparation for future flight tests within the National Airspace System to validate the communications systems and enhanced air traffic management capabilities developed in this program.

Advanced design methods and test techniques to reduce the time and cost of designing commercial transports will be undertaken in the integrated wing design element initiated during FY 1994. Hybrid laminar flow control technology to reduce drag on subsonic transports by inducing smooth laminar flow over the aircraft

surface will be investigated in wind tunnel tests and in computer analysis. In addition, design, analysis and testing methodologies are being evaluated to establish baselines for future activities in high-lift, propulsion/airframe integration, and wing design. The design process used to combine the wing design with engine design will be reviewed to determine how to efficiently combine these separate designs into a single design process that retains the effectiveness of both.

NASA is developing propulsion technology in cooperation with the U.S. industry to increase the competitiveness and market share of the U.S. propulsion industry and reduce environmental impact of future commercial engines through reduced combustor emissions. In FY 1994, the propulsion element has begun with engine system studies to define optimum engine cycles and associated enabling technology needs for the large engine manufacturers. Similar engine system studies are defining technology needs of engines for commuter-sized aircraft. Advanced combustor concepts have been identified and are being evaluated experimentally. Materials for high-temperature sections of the engine are being investigated. All major hardware required for the unique high-pressure/temperature combustion research test rig has been defined.

NASA is seeking to assist in the revitalization of the U.S. short-haul aircraft industry through development and application of new emerging technologies to improve the affordability, safety, utility and environmental acceptability of general aviation/commuter and civil tiltrotor aircraft. In the short-haul element during FY 1994, the industry/government partnership to address the technology development for the general aviation/commuter industry was established. An economic analysis to determine the status of that industry and the areas where technology infusion can contribute to the revitalization of the industry is being conducted. Innovative noise reduction concepts for the civil tiltrotor are being evaluated, and a three- and four-bladed model of the tiltrotor configuration is being tested to establish baselines and trends for noise and aerodynamic performance.

To assist in managing the AST program, to fully understand the relative payoffs of technologies emerging from the AST program, and to provide a foundation for planning subsonic research activities, a study to determine the scope and provide a plan to develop a system analysis capability is the current focus of the technology integration element in FY 1994. In addition, in-house capabilities for modeling and analyzing aircraft, engines, air traffic control, and environment are being improved.

The environmental impact element is addressing the effect of commercial transport aircraft emissions on atmospheric ozone and climate. During FY 1994, studies were initiated in an attempt to identify possible indicators from existing atmospheric observations data. From these studies, plans are being developed for performing additional measurements. Sensitivity studies utilizing computer simulations of atmospheric processes are also being planned.

BASIS OF FY 1995 ESTIMATE

In FY 1995, basic components of fiber-optic controls and electrical actuation developed in the fly-by-light/power-by-wire element will be flight tested and validated on the systems research aircraft. In preparation for commercial transport application of these components, the results of the flight tests will be shared with the U.S. manufacturing industry to support upcoming tests on the transport systems research aircraft. In order to minimize the electromagnetic effects on power management and distribution system components, a method for providing electromagnetic assessments of these components will be incorporated into the fault-tolerant architecture design method.

The focus of the aging aircraft element during FY 1995 will be on inspection methods for detecting small fatigue cracks extending from rivets. A portable, hand-held, battery operated electromagnetic probe developed in this element for detecting small cracks in thin sheet aluminum, and is showing great promise to be low cost and very reliable, will be evaluated by industry to identify further refinement requirements. The analytical methodology to predict the residual strength of a fuselage with fatigue crack and accidental damage will be experimentally verified for an internally pressurized fuselage subjected to loads introduced into the fuselage by the aerodynamic loading on the aircraft tail surfaces. Damage tolerance tests will be conducted with various simulated fatigue and accidental damage to fully exercise and validate the predictive capability of the analytical methodology.

In FY 1995, the jet noise research will concentrate on enhanced mixing nozzles applicable to current engine technology with by-pass ratios in the range of 3 to 6. This research is aimed at increasing the noise margin of current airplanes with respect to current certification standards. Active and adaptive noise control techniques will be tested on a low-power fan model. Ultimately, these active noise control technologies will be used on future aircraft to reduce fan noise radiated from engines. Computational aeroacoustics will be used to guide experiments to develop reduced airframe noise designs for landing gear and other aircraft components. Acoustic imaging will be used to locate the optimal locations of active noise control actuators to reduce the broadband noise heard inside airplanes. An integration of the costs and benefits associated with noise reduction will include such things as the impact of relaxed noise curfews on airplane utility.

In FY 1995, the terminal area productivity element will develop a two-dimensional, unsteady model of aircraft laminar wake vortices in the vicinity of the ground. This model will provide a tool for airport-airspace planners to make decisions on spacing between aircraft. The research flight system will be installed in the replacement transport systems research vehicle to support flight tests of terminal area productivity concepts throughout this effort. Using data such as airline operational schedules, low-visibility weather occurrence, and costs of weather-related disruptions, a study to project potential landing, roll-out, take-off and taxi bottlenecks and estimates of the cost versus benefit of new technical concepts for low-visibility operations will be completed.

In FY 1995, a hybrid laminar flow control model will be tested in the 8-foot transonic pressure tunnel and the results used to improve and guide the development of aircraft drag reduction in the integrated wing design element. A method of determining wing loading on wind tunnel models with a paint designed to change color in response to changing pressure will be undertaken. This will replace a much more expensive instrumentation system requiring the use of surface pressure sensors installed within the configuration being tested. A method for designing the wing and engine simultaneously will be completed. Three-dimensional aerodynamic grid generation for computational fluid dynamic analysis techniques will be developed.

In the propulsion element in FY 1995, experimental evaluation of concepts for advanced low-emissions combustors will continue, with the goal of completing initial screening of concepts in existing rigs. Assembly of the unique high-pressure/temperature combustion research rig will be completed, permitting higher pressure testing of low emission combustion concepts. Materials development and characterization will continue for high-temperature disks and lightweight engine static structures. Efforts will be initiated to improve turbine cooling technology, and improve turbomachinery aerodynamics in both high-pressure compressors and turbines.

During FY 1995, the short-haul aircraft element will continue assessing emerging technologies for use in these aircraft. A ground-based cockpit simulator used to evaluate future communications, weather and situational awareness will be assembled with prototype hardware. The system requirements for the integration of simplified engine control displays, and the integration of these into the cockpit display systems will be completed on the general aviation airborne simulator. The computer operating architecture for future general aviation control and displays will be identified. The innovative noise reduction concepts will be refined and the active source noise control will be evaluated for the tiltrotor configuration. Displays and pilot-to-cockpit interfaces for low noise approaches of the civil tiltrotor will be identified.

During FY 1995, with completion of the plan for integrated aviation systems analysis capability, the technology integration element will initiate development of the executive for this capability and develop plans for implementing integration, operation, and maintenance procedures. To assist environmental impact studies, computational capability will be developed for analysis of the chemical processing which occurs in the mixing of engine exhaust with the background atmosphere. Exhaust trace chemistry for operational engines will be measured.

In FY 1995, the composites element will be initiated. The objective is to develop and verify at full-scale the composite structures technology, including verification of design concepts, structural materials, and manufacturing methods, required for joining composite wings to composite fuselages while saving weight and cost compared to conventional metal commercial transports. During FY 1995, contracts will be awarded for the design, fabrication and test of a full scale wing/fuselage intersection component.

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Hypersonic technology program..................	33,118	26,000	40,000

OBJECTIVES AND JUSTIFICATION

In FY 1994 and prior, the hypersonic research and technology program utilized NASA expertise and facilities in conjunction with university and industrial research to develop advanced, next-generation, high-risk/high-payoff, hypersonic technologies which will provide major innovative ''leaps'' in future hypersonic vehicle performance and help ensure continued U.S. leadership in aeronautics. The program focuses fundamental research and technology development within the disciplines of ram/scramjet propulsion, aero/aerothermodynamics, materials, structures, guidance and control, technology integration, and the improvement of test techniques. Advancements in these disciplines are required to enable future airbreathing, hypersonic launch vehicles, including single and two stage-to-orbit concepts. While the emphasis is on airbreathing accelerating configurations, technology will also be generated for cruise and reentry vehicle configurations. The program has completed a crossing shock experiment in the 3.5 foot hypersonic wind tunnel on a generic inlet to validate improved computational fluid dynamics (CFD) computer codes for turbulence models with compressibility corrections. Design and fabrication of a swept fuel injector has been completed. Its goal is to increase scramjet supersonic combustion efficiencies. Room temperature testing of an advanced carbon-carbon control surface for a hypersonic vehicle has been completed; the test article is now being subjected to temperatures approaching 2000 degrees Fahrenheit. The program is evaluating a hypersonic nozzle code with Single Expansion Ramp Nozzle (SERN) data for incorporation in nose-to-tail CFD codes. A high temperature fiber optic microphone instrumentation device was developed and demonstrated in the Langley Research Center thermal acoustic fatigue test apparatus. The program renewed its effort to develop university centers for training students and conducting research in hypersonic aeronautics. The goal is to provide future experts in multiple hypersonic disciplines for U.S. industry, universities, and the Government. Research grants were awarded to the University of Maryland, the University of Texas (Arlington), and Syracuse University.

Beginning in FY 1995, an affordable hypersonic technology program will be initiated that builds on the technical progress of the completed NASP program and the resources transferred from the base R&T program in hypersonics. This program will focus on the development of the key enabling technologies for hypersonic air-breathing aircraft. The hypersonic technology program will focus on validating scramjet technology through a cost-effective ground and flight-test program. In order to conduct a flight test experiment within a reasonable time frame, it is anticipated that a partnership would be formed with the Air Force to maximize available resources while minimizing overall program risk. This effort will include the

development of supporting technologies (materials, structures, stability and control, aero/aerothermodynamics, instrumentation, etc.), tools and methodologies and advanced vehicle concept assessments.

BASIS OF FY 1995 ESTIMATE

The FY 1995 hypersonic technology program will focus results from the earlier hypersonic research and technology and NASP programs. This program will validate the highest-priority enabling technologies through ground based and flight experiments. Ground based tests will likely include continued validation of the concept development engine (large scale scramjet) in the Langley 8-foot high temperature tunnel with operating speeds up to Mach 8. In areas beyond the capabilities of ground facilities, flight tests will be used to reduce the technological risk in prediction of both hypersonic boundary-layer transition (laminar to turbulent) and of scramjet performance. Concept design, systems operations, instrumentation and other activities will be pursued to support hypersonic flight tests.

CONSTRUCTION OF FACILITIES

	FY 1993	FY 1994	FY 1995	Page Number
		(Thousands of dollars)		
National aeronautical facilities	25,000	181,000	--	
Aeronautics subsonic augmentation (ARC)	25,000	--	--	
Unitary plan 11-foot wind tunnel (ARC)	--	20,000	--	
Modifications to composite technical center (LeRC)	--	27,000	--	
Modifications to NTF for reliability (LaRC)	--	60,000	--	
New facility study/design (HQs)	--	74,000	--	
Aeronautical facilities revitalization	27,600	31,000	22,000	
Rehab of control systems, national full-scale aerodynamics complex (ARC)	--	2,100	--	
Upgrade of outdoor aerodynamic research facility	--	3,900	--	
Modernization of unitary plan wind tunnel complex (ARC)	8,000	25,000	22,000	CF 2-5
Modification to 14 x 22 foot subsonic wind tunnel (LaRC)	2,200	--	--	
Repair and modernization of 12 foot pressure wind tunnel (ARC)	17,400	--	--	
Total	52,600	212,000	22,000	

OBJECTIVES AND JUSTIFICATION

This program continues an effort to upgrade the U.S. aeronautics facilities capability. The U.S. has been increasingly challenged in world aeronautics markets for some time. Since 1984, its share of those markets has dropped with a corresponding loss of numerous aerospace jobs. It is important that this trend be reversed. The new Administration is encouraging implementation of a national goal to infuse the U.S. aerospace industry with the capability to develop a new generation of civil and military aircraft which will outperform the competing products of its international competition at comparable or lower cost. This

program will contribute to that goal by providing the high priority facilities needed to enable development of a significant portion of the required advanced aeronautical technology.

In FY 1994, the essential elements of the construction plan are:

1. Facility studies, definition of requirements, and design of a new or drastically modified set of U.S. wind tunnels based on the results of the National Facility Study.

2. Modifications for Composite Technology Center, Lewis Research Center. This project will construct an addition of approximately 45,000 square feet to the building for composite materials and chemical analysis laboratories. The existing 45 year-old building will be modified to improve life and environmental safety and to improve efficiency of building systems.

3. Rehabilitation of Control Systems, National Full Scale Aerodynamics Complex, Ames Research Center. This project is required to replace obsolete and inefficient control systems in the NFAC.

4. Upgrade of Outdoor Aerodynamic Facility, Ames Research Center. This project enlarges the Outdoor Aerodynamic Research Facility (OARF) N-249, at Ames Research Center's Moffett Field site to support testing of models and aircraft sized for the 80 x 120 foot leg of the National Full-Scale Aerodynamic Complex (NFAC).

5. Modernization of the Unitary Wind Tunnel Complex, Ames Research Center. This project provides funding for the modernization of the Unitary Plan Wind Tunnel (UPWT) Complex to improve production, availability, and quality of test results. Note: This funding is the second increment of funds for this project.

BASIS OF THE FY 1995 BUDGET ESTIMATE

The UPWT is a vital national high-speed tunnel facility consisting of one transonic and two supersonic test sections and supporting auxiliary equipment. This facility is the most heavily used wind tunnel complex in NASA. However, the facility's productivity is limited by the 1950's era control systems and the increasing frequency of equipment breakdowns due to age and heavy use. Modernization is needed now to improve productivity, data quality, and reliability. This complex has been operated on three-shifts-per-day basis since 1956, with minimal improvements to the facility. Tunnel downtime resulting from equipment and control failures has caused major delays to important aircraft projects. The tunnel testing backlog exceeds two years. The lack of modern data acquisition equipment results in over half of tunnel tests being concluded before all needed data is acquired. Comparable foreign facilities have shown two-to-three times the productivity achieved in the UPWT complex.

Repair or replacement of tunnel components that have reached the end of their useful life is required. Also, the welds in the tunnel shelf contain defects typical of 1950's technology and must be repaired and the pressure shell recertified.

This cost estimate provides the FY 1995 increment of funds for the UPWT. Prior funding (through FY 1994) total $35.6 million. The total cost of this project is estimated to be $63.0 million, with the final funding increment of $8.0 million planned for FY 1996.

BASIS OF FY 1995 FUNDING REQUIREMENT

TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Transatmospheric research and technology........	--	20,000	--

OBJECTIVES AND STATUS

The transatmospheric research and technology program is the NASA portion of the joint NASA/DoD National Aero-Space Plane (NASP) program. The NASP program objective is to develop the technology required to permit the Nation to develop reusable, single-stage-to-orbit (SSTO) vehicles with airbreathing primary propulsion as well as horizontal takeoff and landing. The NASP national team consists of NASA, the DoD and a team of five prime contractors (Lockheed (Fort Worth), McDonnell Douglas, North American Aviation Division of Rockwell, Pratt & Whitney, and Rocketdyne). NASA Research Centers will utilize their unique expertise for specific tasks and will continue to support technology-development tests by contractors in their facilities. The exceptionally broad technology base includes propulsion, materials and structures, controls, and applications of computational fluid dynamics. The FY 1994 work emphasizes tests for aeropropulsion and engine structures/materials validation.

During 1994, the national team will complete all documentation on the final design cycle of the X-30 flight-research vehicle. Documentation will also cover results of preparations for subscale, unpiloted flight experiments boosted to test conditions by surplus military rockets. Final documentation will be the primary or only activity in the areas of slush-hydrogen technology, subsystems, and vehicle management systems.

The NASP team will conduct ground-based testing of the ramjet/scramjet Concept Development Engine (CDE) at the NASA Langley Research Center at simulated flight conditions of Mach 7 and 8. Test plans also include large-scale combustor work in the Ames 16-inch Shock Tunnel, inlet tests at Mach 3, 6, and 10, and limited subscale, parametric tests at Mach 5 and 8 to complement the CDE work. Existing actively cooled, engine-type structures (typically 1 x 4-inch units) will be tested; however, fabrication will not be completed on several 20 x 20-inch panels. Also, acoustic/thermal work is canceled on the 2 x 2-foot actively cooled panel. The High-Heat Flux Facility at NASA Stennis Space Center will be phased down and mothballed.

Airframe work will focus on completing acoustic/thermal/mechanical tests of existing panels/structures -- typically of titanium metal-matrix composites (TMC) -- and documentation of the results. Powered models of the final X-30 configuration will be tested from Mach 3.5 to 18. The results of improved modeling of

boundary-layer transition and shock-induced heating as well as related enhancements will be integrated into computational fluid dynamics (CFD) tools.

BASIS OF FY 1995 ESTIMATES

The Transatmospheric Research and Technology program concludes in FY 1994. A restructured hypersonic technology program will begin in FY 1995, as previously discussed.

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1995 ESTIMATES

BUDGET SUMMARY

ADVANCED CONCEPTS AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995	Page Number
Advanced space transportation	114,600	121,900	103,100	SAT 5-5
Spacecraft and remote sensing	140,800	156,000	143,300	SAT 5-10
Flight programs	115,000	97,400	91,600	SAT 5-15
Space communications	33,100	31,000	23,700	SAT 5-21
Space processing	31,900	16,500	19,200	SAT 5-25
NASA technology transfer	29,500	27,800	36,800	SAT 5-29
Advanced smallsat technology	--	12,500	47,900	SAT 5-31
Industry technology program	--	19,700	18,900	SAT 5-32
Construction of facilities				
Rehabilitation of rocket engine test facility (Lewis Research Center)	--	12,500	--	
Small business innovation research and small business technology transfer	(98,825)	(111,511)	123,900	SAT 5-34
Total	464,900	495,300	608,400	

SCIENCE, AERONATUICS AND TECHNOLOGY

FISCAL YEAR 1995 ESTIMATES

BUDGET SUMMARY

ADVANCED CONCEPTS AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Distribution of Program Amount By Installation			
Johnson Space Center	62,698	52,900	66,140
Kennedy Space Center	3,640	2,600	12,077
Marshall Space Flight Center	41,524	49,700	73,683
Stennis Space Center	6,325	8,800	13,004
Langley Research Center	49,601	41,500	68,767
Lewis Research Center	68,918	74,500	54,590
Ames Research Center	27,687	22,900	25,316
Goddard Space Flight Center	22,588	17,500	33,370
Jet Propulsion Laboratory	50,781	50,700	75,795
Headquarters	131,138	174,200	185,658
Total	464,900	495,300	608,400

OBJECTIVES AND JUSTIFICATION

In 1993, the Office of Commercial Programs (OCP) and the Space Technology Directorate of the Office of Aeronautics and Space Technology (OAST) were merged to create a new organization, the Office of Advanced Concepts and Technology (OACT). The OACT is the NASA focal point for technology innovation and transfer. The focus of the new office is the development and application of technologies critical to the economic, scientific, and technological competitiveness of the U.S. and the promotion of U.S. industrial preeminence through strengthened linkages between the private sector and NASA technology efforts. Specifically, the mission of OACT is to pioneer innovative, customer-focused space concepts and technologies, leveraged through industrial, academic, and government alliances to ensure U.S. commercial competitiveness and preeminence in space. Several goals for the new organization have been established:

- to be a center of systems engineering excellence performing concept definition and evaluation studies for NASA, industry, and commercial applications;

- to be a nationally recognized customer-oriented focal point for solicitation, evaluation and implementation of innovative technology and products for space and terrestrial applications;

- to establish new alliances and mechanisms to develop and transfer technology to create new self-sustaining industries, improve performance, reduce costs, and demonstrate benefits and potential of dual-use technology; and

- to develop and promote the unique attributes of space for new commercial products and services.

In FY 1994, programs previously supported through the Space Research and Technology program and the Commercial programs were merged to form a new work breakdown structure which aligned the budget structure so that it was consistent with the strategic and customer-focused efforts that the program supports. Also, in FY 1994 the Advanced Space Transportation program combines space transportation technology efforts previously distributed in several programs: Advanced Concepts and Technology [Space Transportation], Space Systems Development [Advanced programs specifically Advanced Transportation and Solid Propulsion Integrity Program (SPIP), Advanced Launch Technology, and Single Engine Centaur]. Each customer-focused technology program supports a range of technology activities from near- to mid- to longer-term efforts. Each program also involves balanced participation by NASA Field Centers, universities, and industry, including such

innovative arrangements as the Centers for the Commercial Development of Space (CCDS). The new structure merges both the technology and commercial elements into one OACT budget which is organized by customer focus. These are advanced space transportation, spacecraft and remote sensing, space communications, and space processing. In addition to these four technology programs, two other program elements have been developed: (1) technology transfer which supports the necessary infrastructure and networks to foster the transfer of technology from NASA laboratories to U.S. industry and (2) flight programs which supports the development of commercial and technology experiments and carriers. In addition, two new initiatives were initiated in FY 1994 as part of the Administration's technology policy, the advanced small satellite technology program and the industry technology program. With regard to the clean car initiative, NASA will respond to the Department of Commerce-led clean car initiative with a supporting program to help develop the next generation of environmentally sound, fuel efficient automobiles after a program plan has been established.

The Administration is presently conducting an interagency review of the National Space Launch policy to determine a future course of action for supporting near-, mid-, long-term space launch requirements. This review is being conducted over the first half of 1994. The NASA program plan and budget for advanced space transportation research and technology development activities will be altered consistent with the policy determinations of the Administration and will be submitted to the Congress in accordance with established procedures.

BASIS OF FY 1995 FUNDING REQUIREMENT

ADVANCED SPACE TRANSPORTATION

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Technology assessment and development...........	37,600	45,100	37,200
Advanced technology maturation..................	35,700	51,000	56,600
In-Space transportation.........................	31,300	15,800	9,300
New launch system (NLS).........................	10,000	--	--
Single engine centaur	--	10,000	--
Total..................................	114,600	121,900	103,100

OBJECTIVES AND STATUS

The objective of the Advanced Space Transportation program is to develop the technologies to support current and future space transportation systems which are significantly less-costly and more reliable, operable and robust. Emphasis will be placed on evolving high-payoff technologies critical to the attainment of this objective. Technologies applicable to existing systems (Shuttle and the Expendable Launch Vehicles (ELV's)) are supported on a selective basis to provide an effective space transportation system until a new, more effective system can be developed. These activities will be closely coupled with the Shuttle program office, the ELV industrial organizations and the Department of Defense (DoD) as appropriate. The program is comprised of technology assessment and development, advanced technology maturation, and in-space transportation activities. The Advanced Space Transportation program combines space transportation technology efforts previously distributed in several programs: Advanced Concepts and Technology [Space Transportation], Space Systems Development [Advanced Programs specifically Advanced Transportation and Solid Propulsion Integrity Program (SPIP), Advanced Launch Technology, and Single Engine Centaur].

The program develops and validates technologies for current and future space transportation systems enabling their development at reduced cost and schedule risk. The program includes propulsion, vehicle materials and structures, avionics, supporting systems, and operations technology activities for both launch vehicles and in-space systems. Efforts range from near-term activities applicable to the Shuttle, existing ELV's and near-term vehicle development efforts, to far-term efforts to provide an understanding of the potential of very advanced propulsion concepts which will form the basis of revolutionary, twenty-first century space vehicles. It provides and maintains conceptual design and analysis capability (analytical and experimental) and a base of technology to support the initial design and the development efforts. Technical areas include analytical and experimental capabilities required to assess aerodynamic performance, vehicle structural

weights, sensitivity to structural materials, engine performance and complex hypervelocity flow environments. Experimental facilities supported exclusively by this element are the Langley Research Center (LaRC) Hypersonic Facilities Complex (provides performance characteristics for design optimization and validation of aerothermodynamic computational codes incorporating real-gas chemistry effects); and the Ames Research Center (ARC) Arc Jet Complex (supports validation of advanced thermal protection materials).

In early FY 1994, NASA in coordination with the Departments of Defense and Transportation, completed an Access-to-Space assessment of future space transportation options. NASA's assessment of these options is being considered in the Administration's ongoing policy review of space launch. One finding of NASA's assessment was that there is an opportunity to make additional technology investments which could later support development of a new space transportation system with lower-cost and better reliability, operability and robustness. The potential of this opportunity to provide the U.S. with a competitively superior launch system was considered to be significant. Depending on the Administration's future policy determinations, specific technology development plans can later be developed and pursued in close coordination with industry, the Department of Defense, and other federal agencies.

In the propulsion area, several advanced main combustion chambers (AMCC's) will be tested in the Space Shuttle Main Engine (SSME) technology testbed for final verification of a new fabrication method. For the SSME application, the AMCC's are expected to cost one-sixth as much as the current main combustion chambers, require one-third the manufacturing time, and substantially reduce the number of welds and the operating temperature. In cooperation with McDonnell Douglas and TRW, hot fire tests of a potentially low fabrication cost rocket engine concept, using a pintle injector-ablative thrust chamber design have been conducted at the Lewis Research Center (LeRC). In an associated cooperative effort, Allied Signal foil bearing turbopumps have been tested, using liquid hydrogen and liquid oxygen, at the Stennis Space Center (SSC) and the Marshall Space Flight Center (MSFC), respectively. The hybrid motor program is developing a data base to define critical performance and safety characteristics; this is a cooperative NASA/industry effort using industry developed and supplied test hardware which is hot-fired in NASA facilities. Electromechanical actuators for thrust vector control and engine valve positioning are being developed and tested in simulated environments.

In-space transportation technology activities include advanced chemical engines, solar electric flight systems, on-board propulsion and advanced propulsion concepts, and other space vehicle systems. On-board propulsion has seen significant breakthroughs in an area that comprises 25 percent to 50 percent or more of the mass of a spacecraft. In late 1993, a commercial (Telestar) satellite using NASA-developed arcjet thrusters for station-keeping was successfully launched. The higher performance of these thrusters resulted in a substantial reduction to spacecraft weight enabling the use of an Atlas in lieu of an Ariane 4 launch vehicle. Because of the potential to reduce the spacecraft propulsion system weight, permitting reduced spacecraft weights, reduced trip times and increased scientific yields for near-Earth and outer planet missions, ion thrusters are one of the science community's highest technology priorities. A joint effort

with the NASA Space Science Program Office, the Air Force and industry, will conduct a flight experiment of an ion propulsion system which will reduce launch weights and trip times and provide for increased scientific yield from near-Earth and outer planet science missions. Longer range efforts to evaluate very advanced propulsion system concepts are also included. The advanced propulsion concepts program continues to explore high-leverage, high-performance concepts for future propulsion needs; for example, the modeling of an anti-proton-catalyzed inertial-confinement fission/fusion concept was completed and development has begun of a portable anti-proton container which will be used by the Air Force to conduct a proof-of-concept demonstration. Because of the possible use of unmanned vehicles to service in-space vehicles or resupply the Space Station, an automated rendezvous and capture capability is being developed and preliminary concepts for an in-space demonstration are being formulated.

Materials developments includes technology for more durable thermal protection system (TPS) materials and lightweight reusable cryotank concepts using Aluminum-Lithium alloys and graphite composites. Support is being provided to the Mars Environmental Survey (MESUR) Project Office at the Jet Propulsion Laboratory (JPL) to accurately define forebody heating for TPS selection and afterbody heating resulting from unexpected recirculation in the wake flow region effecting sensitive communications antenna and parachute mechanisms. A cooperative technology activity with General Dynamics and Martin Marietta is developing low cost fabrication processes for lighter weight aluminum-lithium cryogenic tanks and launch vehicle structure. The goal of this LaRC-led effort is to reduce structural weight by 20-30 percent and manufacturing cost by 30-40 percent.

To significantly reduce the cost of placing small (half-ton class and smaller) payloads into orbit, NASA is investigating the opportunity for cost-shared developments using joint government/industry teams to design, develop, and test new concepts to replace the expendable solid rocket-based systems in use today. Reusable, liquid-fueled booster stages and liquid-fueled upper stages are prime contenders.

The program includes systems definition and preliminary design (Phase B) studies. These provide the necessary technical and programmatic data needed to assess evolving space transportation and systems requirements and to evaluate new technical capabilities. Studies define flight systems options to satisfy near-term and longer range national space transportation requirements in sufficient detail to select cost effective pathways and guide technology. Systems include expendable, partially reusable and fully reusable two-stage and single stage vehicles.

The SPIP, is developing a comprehensive database to improve the engineering understanding of solid rocket motors to enhance their reliability. In FY 1994, the database and analytical tools for resolving nozzle ply-lift phenomenon will be developed, the bondline "issues" will be resolved, and the low-cost combustion simulator design will be completed permitting initiation of facility modification.

The program is supported by flight experiments, a system analysis capability, and a university based research program. Continued emphasis will be placed on facilitating the transfer of emerging technologies to the commercial space transportation industry and on developing cooperative agreements for application of technology advances to non-aerospace organizations and industry.

BASIS OF FY 1995 ESTIMATE

In partnership with industry and in coordination with DoD, the program will invest in critical, high-payoff technologies. Projects include light-weight, robust propellant tankage and primary structure and high-performance propulsion systems with sufficient margins and health-statusing to attain the reliability, operability and robustness goals. The tankage projects will address technology for a reusable cryogenic capability (materials, certification for flight, and the insulation system); the identified material options include aluminum-lithium and graphite-composites. Reusable launch systems will also require reusable, light-weight thermal protection systems which do not require the extensive servicing of existing systems. Propulsion projects will address dual-fuel options (using both LH2 and radio frequency (RP) with LOX), and advanced engine designs (an example is the linear aerospike engine). Appropriate Russian technology and systems will be considered, with particular emphasis on their extensive experience base in high-pressure LOX-hydrocarbon engines. Business relationships between Russian design bureaus and U.S. industry organizations will facilitate these efforts.

Propulsion efforts focused on the reduction of Shuttle costs will continue at a reduced level focusing on improved operations. These are cooperative efforts with the Shuttle program office. In addition, some propulsion related efforts such as hydrogen leak detectors, improved sensors and other vehicle heath management technologies will be completed at the engine test and launch sites.

Cooperative efforts to reduce the cost of existing commercial launch vehicles of all sizes will be expanded, initiating industry-driven, cooperative activities resulting from the broad solicitation to industry issued in FY 1994. NASA will continue support for the industry hybrid motor test program. The FY 1994 initiated funded activities will be completed.

The SPIP will focus on nozzles, verification testing, and on infusing technology engineering results and cultural changes into flight programs. The program will continue to sustain the NASA-industry nozzle team and infrastructure across the U.S. solid motor community with steady advances in engineering data bases, analytical tools for design, fabrication and verification. The program will also deliver the results and findings of the bondline effort, and complete the combustion simulator facility.

System analysis and technology assessment activities, experimental and analytical capabilities required to support future technology definition and development decisions will be continued.

A multiyear funding plan and schedule of annual performance milestones for the development of a single-engine Centaur will be developed and provided to the Congress; no funding will occur until the report is accepted.

By the end of FY 1994, all work on chemical upper stages will be terminated. Ground test and flight system design efforts for the ion engine flight experiment will continue with a planned flight test of an ion system on-board an Air Force vehicle in FY 1998. Support for efforts in the area of on-board propulsion will continue at a reduced level, with emphasis being placed on those activities with high industry interest and cooperation. Assessment of very advanced propulsion concepts will continue at various academic institutions. Funding for the transportation-related University Space Engineering Research Centers at Pennsylvania State University and the University of Cincinnati will be terminated by the end of FY 1995.

BASIS OF FY 1995 FUNDING REQUIREMENT

SPACECRAFT AND REMOTE SENSING

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Earth applications systems	50,900	60,100	57,100
Space and planetary systems	50,800	58,800	52,800
Space platforms systems	39,100	37,100	33,400
Total	140,800	156,000	143,300

OBJECTIVES AND STATUS

The Spacecraft and Remote Sensing program is pioneering innovative spacecraft and remote sensing technologies and applications to meet the needs of the civil space program and commercial users. Working closely with the future users of the technology products, the objectives of the Spacecraft and Remote Sensing program are to advance a broad spectrum of engineering technologies that generate new concepts, and to validate technologies that advance the state-of-the-art in spacecraft development in support of Mission to Planet Earth (MTPE), space science missions and space platform applications. The program focus is on enabling an evolution toward physically smaller, lower power, less expensive, but more capable spacecraft, which allow NASA to continue the enterprises of understanding the Earth, discovering the fundamental nature of the universe, and initiating steps toward human exploration.

This program features work in advanced composites, integrated spacecraft design concepts, as well as the demonstration of a companion set of micro-instruments. Light-weight space power concepts and systems including batteries, photovoltaic arrays and light weight thermal systems are demonstrated. The program develops detectors and measurement systems that will increase the resolution and data return from the next generation of science spacecraft and in the longer term allow scientific measurements in new regions of the electromagnetic spectrum. Our efforts to assist in the development of a viable commercial remote sensing industry include prototyping of specialized packaging of space data into usable customer defined products. Robotic technology is being advanced through flight demonstration of existing microrover technology on the Mars Environmental Survey (MESUR) Pathfinder mission, which is being pursued jointly with the Office of Space Science. Operations technology emphasizes the insertion of new approaches to reduce the life cycle cost of science missions and the archiving and analysis of resulting scientific and commercial information. Across the entire Spacecraft and Remote Sensing program there is increased emphasis on and concentration of resources on the highest priority Agency activities, on technology dual use, and on interagency activities to advance national competitiveness.

The spacecraft and remote sensing program is organized into three areas which support three customer foci: (1) Earth application systems, (2) Space and planetary systems, and (3) Space platforms systems. In the Earth applications systems element, the principal customer is the MTPE program; but this area also includes efforts for the commercial remote sensing industry and for non-space commercial applications. Discipline work areas include Earth orbiting spacecraft subsystems, such as structures and materials, power, thermal control and vibration isolation; operations technology for infusion into future improvements in the Earth Observing System (EOS) data information system (EOSDIS); and sensors and data processing systems that support the achievement of Mission to Planet Earth scientific objectives. Specific work elements include tasks on large format, long-life visible and infrared detector arrays which will be used for Earth surface temperature and emissivity measurements, submillimeter components for extending the measurement out to the 2.5 Terahertz spectral band; and prototype micro-instrumentation for remote and in-situ science sensing applications.

In FY 1994, a number of small commercial applications have been initiated in areas where NASA space-derived engineering expertise and facilities will contribute to near-term commercial needs and opportunities. The set of applications includes multiple applications of the capabilities of the Microdevices Laboratory at the Jet Propulsion Laboratory (JPL), superplastic forming and advanced electronics with the automotive industry, nickel electrode development with United States Automobile Battery Consortium and several advance materials research efforts.

A number of significant technical accomplishments that are directly applicable to Earth science missions were achieved in FY 1993. The Lidar In-Space Technology Experiment successfully completed all the preflight subsystems and integration testing. In FY 1994, the Laser In-Space Technology Experiment flight hardware was completed and successfully ground-validated for its Shuttle flight scheduled for September 1994. The fabrication of a 30-degree Kelvin, two-stage Stirling Cooler was completed and characterization testing was initiated. This cooler has been specifically developed in collaboration with MTPE, but it has multiple applications to all infrared and x-ray instruments that require low vibration and sustained cooling in the temperature range between 30 and 70 degrees Kelvin. The two-micron, solid-state laser analytical modeling, development and characterization program identified a Holmium and Thulium doped Lutetium Aluminum Garnet (Ho:Tm:LuAG) as a likely candidate for characterization. Subsequent experiments demonstrated that Ho:Tm:LuAG has a 25 percent higher light conversion efficiency than existing solid state laser materials.

In the space and planetary applications program, the customers are the astrophysics, space physics, and robotic solar system exploration flight programs of the Office of Space Science. The engineering emphasis includes spacecraft technology infusion programs focused on near Earth and deep space probes, the MESUR Pathfinder rover flight hardware development, spacecraft subsystems technology, advanced rover technology, sensors and instrument technology, telescope optics, and operations. The purpose of the technology infusion program is to eliminate the barrier to technology transfer into flight projects and to assure the continuous transition of advanced technology into NASA spacecraft projects. In both the near Earth and deep space

probes programs, the projects have identified highly focused technology enhancements that have specific quantifiable benefits for specific missions. The technology developers have been given performance metrics that must be achieved for their subsystem to be included on specific flight programs. In the area of telescope technology the objective is to initiate a program demonstrating cryogenic mirrors and telescope assemblies for future NASA, commercial and defense applications. The goals of the MESUR Pathfinder rover program are to demonstrate that a low cost microrover can be provided to the project which is capable of imaging the lander on the Martian surface, acquiring compositional data on rocks and soils using an alpha-proton x-ray spectrometer, and obtaining engineering data to guide the development of future Mars microrover systems.

The examples of significant technical accomplishments in our space and planetary activities include the programs contribution to the modeling of the prescription for the Hubble Space Telescope optical correction repair and the electrostrictive ceramic actuators that will be used for adjusting the Wide Field Planetary Camera actuated fold mirror; the first demonstration of 670 GHz superconductor mixer performance which opens up this wavelength to comprehensive astronomical study and the application of an OACT-developed antimony impurity band conduction silicon detector to obtain unparalleled imagery of the galactic center in the 20 to 40 micron range. Fiscal Year 1993 was the year the Erebus Explorer Remote Robotic Rover system was in one year's time, designed, fabricated, and field tested in Antarctica including demonstration of remote operation, autonomous navigation and walking. In the power area, Indium Phosphide photovoltaic cells were demonstrated with a ten times improvement in radiation tolerance over state-of-the-art gallium arsenide (GaAs) cells. In the area of structural materials, rapid fabrication (30X) of carbon-carbon spacecraft components was demonstrated using a rapid densification fabrication innovation. The first use of the SkiCat automated astronomical cataloging tool for use on the CalTech Mt. Palomar total sky survey also occurred during FY 1993.

The customers for the space platforms technology program are the offices of NASA that are responsible for Earth orbiting space stations, future large communications antennas, and planetary orbiters. All of these applications require efficient and compact energy systems, stable structures and environmentally compatible materials which requires understanding of space environmental effects. Many missions are dependent on precise pointing and a quiescent environment for successful performance. Specifically, jitter reduction of a science instrument can improve data quality (resolution) and reduce cost and improve data timeliness through reduced data processing requirements. The objectives of the space environmental effects program are to develop, document and disseminate information which will improve environmental and effects modeling, reduce risk and accelerate ground based facilities and test guidelines. Space platforms also have a need for minimizing the requirement for human extra vehicular activity (EVA) by telerobotic maintenance systems, science payload tending and capture/manipulation of external objects. Telerobotics provides many dual use technology applications and the program hopes to see emerging industry in a number of areas such as micro-surgery, construction, agriculture, and entertainment applications. Space platforms also present some of the most significant operations challenges. The platform operations programs goal is to infuse technology

into station operations to improve efficiency, reduce costs and risks by developing automated monitoring and diagnosis, provide tools for developing automated diagnosis systems and automation of power system management expert systems.

Technical accomplishments relevant to the platform include completing the assessment of the Long Duration Exposure Facility flight results and initiation of a space environmental effects design handbook, demonstration and transfer to NASA of the Flight Telerobotic Servicer Arm; and development of the linear Fresnel solar concentrator concept which simplifies photovoltaic array design and has a projected cost reduction of one third. The Hazardous materials handling robot (HAZBOT) development was completed and the robot was turned over to the JPL fire department for training and user evaluation.

Each of the three major program application areas also has specific systems analysis studies underway to refine the definition of critical technologies for future high priority missions. In most cases, these studies are performed in cooperation and co-funded by the user offices. Finally, support for four centers for the commercial development of space which are working on related technologies will continue. These centers are the Center for Mapping (Ohio State), Space Remote Sensing Center (Stennis Space Center), Center for Space Power and Advanced Electronics (Auburn University), and the Center for Space Power (Texas A&M). Their respective efforts are focused on the following technologies -- high resolution map technology, remote sensing for natural resource management, advanced electronic systems and components, and space power generation, conversion and transmission.

BASIS OF FY 1995 ESTIMATE

In FY 1995, the Spacecraft and Remote Sensing program will continue to emphasize technologies that support the NASA's objectives of an evolution to smaller, less expensive, more capable spacecraft that will be able to launch on a more frequent basis with less budget risk per flight. Increased program emphasis will be on dual use technology and on participation in supporting interagency activities to advance national competitiveness. Program funding requirements will be minimized by consolidating Research and Technology (R&T) activities at every opportunity concentrating discipline technology responsibility at the fewest possible NASA Centers. Programs being supported include solar dynamic technology supporting the joint NASA Russian Space Station activity and use of aerospace technologies for the national clean car initiative currently under review.

Some of the specific spacecraft subsystems tasks that will be pursued in FY 1995 include deployable/inflatable designs for antennas and solar arrays to reduce launch volume by 50 percent, documenting the reductions of fabrication time and cost for carbon-carbon spacecraft structures by using a rapid densification process, and multiband gap planar photovoltaic arrays that are projected to have efficiencies greater than 25 percent and ten-year space performance degradations of less than two percent. In operations, the FY 1995 program will develop and infuse into EOSDIS advanced concepts for automated user

friendly data archiving, image data registration and data visualization and analysis. The sensors and instruments program will emphasize demonstration of efficient long-life, high pulse-energy/power lasers for wind and atmospheric chemical composition measurements.

A major focus will be to stimulate commercial remote sensing markets by providing flight testbed opportunities as well as user specific, multi-spectral sensor development and customized software data analysis systems. This area has a very high commercial potential and only a small part of the market has been exploited. By the end of FY 1995, we anticipate the completion of four Space Act projects which will include comparable industrial co-funding, thereby assuring commitment to utilization of technology.

The results of the technology infusion effort should be seen as the advanced technologies for a possible Pluto fast fly-by mission will complete breadboard testing and final technology selection. The second generation of technology infusion candidates will be chosen. Spacecraft technology has become central to the Agency's goal of small, lower cost spacecraft that can be flown with increased frequency. The spacecraft technology program will develop and demonstrate improved space durable polymers for films and composite matrices, the baseline interferometer testbed will become operational, and a 100 milliampere hour Lithium polymer battery will be demonstrated. The rover technology program will demonstrate a range of cheaper, better planetary rovers systems for science instrument placement and planetary surface exploration. By the end of FY 1995, a 100 meter micro-rover traverse will have been demonstrated and a representative science payload servicing demonstration will be achieved. Subscale silicon carbide panels for cryogenic infrared primary mirrors will be fabricated and characterized. A number of operations technology demonstrations should demonstrate ways of greatly reducing mission operations costs. These include operational use by the deep space network at JPL of automated link monitoring and control systems, wide distribution of an artificial intelligence-based astronomical plate analysis system, and demonstration of remote operational control of Extreme Ultraviolet Explorer (EUVE) spacecraft and science experiments from the University of California at Berkeley. In FY 1995 the completion of the MESUR Pathfinder Rover flight unit will also be seen.

The space platforms program will be demonstrating several systems on the control structures ground testbed such as a TRW active mount system and a two kilowatt solar dynamic system. The space environmental effects program will complete the first generation of environmental interaction design tools and participate in the flight opportunity. In FY 1995 the free flying demonstration of a remote operations robot in the KC-135 aircraft and an initial integration of an on-orbit manipulation testbed for Space Shuttle based servicing should be seen. Prototype console software should be delivered to the Johnson Space Center (JSC) for testing. The test of the power expert system demonstration should also be completed.

BASIS OF FY 1995 FUNDING REQUIREMENT

FLIGHT PROGRAMS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Program definition	6,100	400	200
Flight experiments	29,000	30,200	30,600
Space station utilization	100	--	15,000
Experiment carriers and transporters	74,200	60,700	43,400
COMmercial Experiment Transporter (COMET)	(22,800)	(14,500)	(--)
Commercial Middeck Augmentation Module (CMAM)	(51,400)	(45,000)	(41,100)
Experiment preparation, integration, and mission management	5,600	6,100	2,400
Total	115,000	97,400	91,600

OBJECTIVES AND STATUS

The overall goals of the flight programs are to validate advanced technologies and manufacturing techniques; to investigate space environmental effects; and to provide access to space for industry, universities, and government. These goals will be accomplished through the following specific objectives: to develop flight experiments to enhance U. S. industry competitiveness and satisfy space research and technology program requirements; to obtain launch vehicles and carriers for these flight experiments; to provide for technology transfer to users; to stimulate participation and investment of industry in commercial development of space; to maintain a high degree of student/university involvement in flight experiments; and to reduce cost and schedule risks for future space missions. Five elements are supported by flight programs: program definition; flight experiments; Space Station utilization; experiment carriers and transporters; and experiment preparation, integration and mission management. A description of the objectives and status of the elements of the Flight programs follows.

Program definition provides for analysis and studies for future space carriers, such as Space Station, and for program definition, such as defining program policy for small flight experiment implementation and strategic and tactical planning. This element currently involves two field centers. The Langley Research Center (LaRC) serves as the primary interface for the Office of Advanced Concepts and Technology (OACT) technology experiments with the Space Station organizations ensuring that the Space Station can accommodate the broad range of technology experiment requirements. The Jet Propulsion Laboratory (JPL) provides support such as defining new initiatives, program policy for small flight experiments implementation, and strategic

and tactical planning. In FY 1995, the Space Station support will become part of the Space Station utilization program.

The flight experiments budget provides for the development of small experiments to advance space technology concepts which have been developed within NASA, industry, and university facilities and which require flight evaluation and validation in the relevant space environment to reduce the risk of incorporating these concepts into advanced space systems. A major component of this program is the In-Space Technology Experiments Program (IN-STEP) which was initiated in 1986. In FY 1993, 352 proposals were received from U.S. industries, universities, and government agencies in response to the 1992 IN-STEP Announcement of Opportunity which solicited proposals for the validation or verification of advanced space technologies in the microgravity and space environment. Of the 352 proposals, 27 proposals were received from university students for a special streamlined two-year, $200K experiment designed to provide first hand space flight experience to promising graduate students. Over 50 percent of the proposals received involved collaborations with other organizations. In FY 1994, 51 of the proposed experiments were selected and will begin a nine-month Phase A feasibility study. These selected experiments represented 109 participants from U.S. industries, universities, and government organizations located in nineteen states.

In FY 1993, experiments from previous IN-STEP solicitations were flown with successful results. These results will aid in the design of future space systems utilizing supercooled fluid storage; will lead to improvements in current heat pipe computer modeling techniques and predictive capabilities; and will aid thermal system engineers in designing future spacecraft. The results from the heat pipe experiment have already reduced the amount of ground testing required for current spacecraft heat pipes. Other accomplishments include the second flight of the Orbital Acceleration Research Experiment (OARE) as part of the Orbiter Experiments (OEX) program. The data collected over the years by the twelve OEX experiments have been an important source for designing and developing performance improvements in the present orbiter program and have supplied data for validating models for the design of future space transportation vehicles. The OARE measures linear accelerations (to an accuracy of 10^{-9}g) and is the most sensitive three-dimensional accelerometer of its kind ever flown on the Shuttle. Validated over three separate missions, the technology will be transferred to the Office of Life and Microgravity Sciences and Applications for their use with future microgravity payloads. In FY 1994, nine flight experiments are manifested for Shuttle launch. The last OACT flight of OARE was in October 1993. Six small experiments on a common Hitchhiker carrier in the Shuttle bay and a middeck reflight will be launched on STS-62 scheduled for March 1994. These experiments will support the measurement of the spacecraft glow phenomena, the collection of data on the freeze-thaw behavior of molten salts (which are needed for the design of thermal energy storage systems); the investigations of advanced thermal control technology; the measurement of solar cell arcing under high voltage conditions; an advanced space radiation measurement device; and measurement of nonlinear structures dynamics to better understand effects of microgravity. Results of these experiments will serve to aid in the design of Space Station and other future advanced spacecraft. Also, the Lidar In-Space Technology Experiment (LITE) is scheduled to be launched in September 1994 and is aimed at verifying the technology

readiness of using a Lidar (solid state laser) in space for measuring critical atmospheric parameters such as cloud top heights and aerosols.

The objective of the Space Station utilization program is to plan for, select, approve, design, develop, and integrate OACT flight experiments and facilities to be placed on Space Station. These flight experiments and facilities will be selected on the basis of the highest priority technology and commercial benefits that can be derived from the unique Space Station environment, i.e. long duration, low gravity, and radiation coupled with human interaction. This program will also serve to strengthen the established aerospace industry, nurture emerging space industries, and promote aerospace engineering education. Plans are underway to release an Announcement of Opportunity in the second half of FY 1994 to solicit small experiments for Space Station and award approximately twenty Phase A feasibility studies in FY 1995.

The experiment carriers and transporters budget obtains launch vehicles and carriers for OACT flight experiments and stimulates participation and investment of industry in the commercial development of space. The major component of this program is the Commercial Middeck Augmentation Module (CMAM) contract. The CMAM contract with SPACEHAB, Inc. involves the lease of flight accommodations and associated supporting services. In FY 1993, the first SPACEHAB flight under the CMAM contract carried 22 experiments, twenty of which were sponsored by OACT. The second flight of SPACEHAB is scheduled for early 1994 with thirteen experiments, twelve of which are sponsored by OACT. This second flight of SPACEHAB and the experiments contained within it, highlights a continuing cooperative effort between government and industry in using the benefits of microgravity to foster economic growth as well as improve life here on Earth. The CMAM contract is proceeding successfully this year after a restructuring under the new funding profile as a result of FY 1994 Congressional appropriations action.

Another major component of the experiment carriers and transporters program is the COMmercial Experiment Transporter (COMET) which is planned for its first mission in March 1994. The COMET program's goal is to be the nation's first commercial provider of reliable, cost-effective space transportation and recovery services to industry, government, and academic research institutions. However, due to substantial cost growth for the planned three mission program, NASA will conduct an in-depth review of the COMET program in early 1994 and provide findings and recommendations to Congress regarding plans to proceed with mission one. No funds are being requested in FY 1995 for additional COMET missions. In addition, the experiment carriers and transporters program includes a series of testbed transportation systems to optimize access to microgravity, such as KC-135 aircraft flights. These systems provide short-duration microgravity flight opportunities at a low cost for investigators to evaluate concepts and flight hardware before committing to higher cost space flight opportunities. The experiment carriers and transporters program also includes the launch voucher program. The voucher program supports commercial launch and payload integration development efforts by the private sector and provides a more flexible manner of government acquisition of commercial launch and payload support than the traditional procurement practices.

The experiment preparation, integration, and mission management budget provides services for the OACT flight experiments. Several of the payloads require optional services such as late access for biotechnology investigations that are not included in the standard processing template. This element funds these services as required. During FY 1993, overall manifesting support was provided for 35 CCDS payloads and 32 payloads are planned for FY 1994. During FY 1993, optional services were provided for six payloads and will be provided for five payloads in FY 1994. Also, during FY 1993 and much of FY 1994, the CCDS payload developers were provided with technical information to accelerate the development of independent mission capabilities, and also to obtain Program Office-level manifesting and flight documentation support. In addition, experiment integration activities are provided which includes thermal design, safety, mission operations, design, fabrication and qualification of unique hardware required for the integration onto carriers such as Hitchhiker and Spartan. In FY 1994, the Goddard Space Flight Center (GSFC) performed all the integration activities for six IN-STEP flight experiments on a common Hitchhiker carrier scheduled for launch on STS-62 in March 1994.

<u>BASIS OF FY 1995 ESTIMATE</u>

The major focus of the program definition element will be in defining new initiatives, program policy for small flight experiments implementation, and strategic and tactical planning. In the flight experiments element, eleven of the experiments in Phase C/D are scheduled to be launched of which four will be on a common Hitchhiker carrier in the Shuttle bay. These four experiments will support the measurement of damping to improve understanding of mechanical joints and large space structures; demonstration of an integrated two-phase thermal control system (TCS) to provide reliable, efficient TCS for high power spacecraft; and, development of fluid resupply to allow maximum use of tank volume in future spacecraft designs. The other seven experiments will determine specie accretion, velocity direction, and chemistry of spacecraft contamination to improve contamination modeling techniques and prediction codes; characterize the space radiation environment; validate operation of an active cryogenic thermal control system; investigate the control structures interaction of an actively controlled, flexible, articulating, multibody platform; validate performance of static-feed water electrolysis for future long-term life support in space; evaluate heat pipe performance; and measure dynamics of liquids in spinning tanks. In addition, the experiments selected from the 1992 IN-STEP Announcement of Opportunity will be entering into Phase B Project Definition of the experiment implementation process after a competitive down-select process in late FY 1994. The feasibility study phase for these advanced technologies was initiated in FY 1994 and only those flight experiments providing the greatest technological value will be continued through to flight evaluation and demonstration in the microgravity environment.

The Space Station utilization program will support approximately twenty proposals for Phase A feasibility study and a competitive down-select process of which eight to ten of these studies will be selected and will begin a Phase B Project Definition activity. In addition, several experiments which have been developed and are (or will be) flying on Shuttle as precursors to Space Station experiments will be refurbished to fly on

Space Station. Examples of potential Space Station experiments are zeolite crystal growth, commercial crystal growth from solution, physiological systems experiments, bioregeneration of water, sintered and alloyed materials, and solar dynamic power units. These precursor Shuttle flights have established the feasibility and Space Station could enable the development of production prototypes. The results of these experiments are expected to lead into viable commercial products such as better pharmaceuticals, contact lenses, semiconductor materials, etc. In addition, unique Space Station facilities will be required by some of these experiments and plans include the development of required facilities such as a multipurpose glove box and/or an exterior attachment facility to investigate space environmental effects. In addition, as part of this element, a program has been defined to jointly develop with the Russian Federation a technology experiment to facilitate the eventual use of solar dynamic power for the international Space Station.

This program is envisioned as being conducted in two phases, with the first phase being flight demonstration of a subscale unit and the second phase being production and delivery of two 10 kW units for Space Station. The flight demonstration of the subscale unit is planned for 1997 on either the U.S. Shuttle or the Russian Mir-1. Space Station flight units would be planned for delivery in 2001. The Russian Federation would provide the deployable concentrator/radiator and deployment controls and the module orientation system and controls. The U.S. would provide overall system and module integration and controls, heat receiver and power conversion and controls, integrating structures, and launch and on-orbit vehicle integration.

The experiment carriers and transporters program includes the third flight of the CMAM scheduled for launch on STS-63 in January 1995. This effort includes use of the commercially-developed CMAM flight modules and trainers, physical and analytical integration services, training of flight crews, and support to experiment flight operations. The OACT has developed an experiment candidate list which reflects 100 percent NASA utilization on this flight. The fourth CMAM flight is scheduled for October 1995 which also includes 100 percent NASA usage. The CMAM will support fifteen payload tests in FY 1994 and 1995.

As part of this element, to optimize access to microgravity environment, a series of testbed transportation systems, such as KC-135 aircraft flights are planned. These aircraft flights provide additional short-duration microgravity flight opportunities at low-cost for investigators to evaluate concepts and flight hardware before committing to a space flight. In addition, the launch voucher program demonstration will consist of six launches planned to be completed by the end of FY 1995, of which one will be sponsored by OACT in the fourth quarter of 1995.

The experiment preparation, integration, and mission management program supports preparation, integration, and mission management services for the OACT flight experiments. Many of the commercial biotechnology experiments require late access and other optional services that are not included in the standard processing template and are covered by this program. The IN-STEP experiment integration activities include thermal design, safety, mission operations, design, fabrication and qualification of unique hardware required for the integration onto carriers such as Hitchhiker and Spartan.

Mission management support will be provided for four Commercial Development of Space payloads and the preparation and integration activities will be provided for the OAST Flyer mission and the OAST-3 mission. The OAST Flyer mission, manifested for mid-1995, will make use of the Spartan carrier which will be deployed from the shuttle bay for approximately 40 hours as a free flyer. This Spartan will carry three experiments of which one is funded by OACT. The OAST-3 mission, manifested for late 1995, will carry four flight experiments mounted on a common Hitchhiker. These experiments will benefit future spacecraft designs.

BASIS OF FY 1995 FUNDING REQUIREMENT

SPACE COMMUNICATIONS

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Near earth communication systems................	22,000	20,500	16,400
Deep space communication systems................	1,900	2,000	3,200
Space terrestrial hybrid systems................	1,100	1,000	900
Applications experiments........................	8,100	7,500	3,200
(ACTS Experiments and Operations)...............	(7,900)	(7,400)	(3,000)
Total...................................	33,100	31,000	23,700

OBJECTIVES AND STATUS

The Space Communications program reflects NASA's role as maintaining a significant research and development (R&D) effort in space communications to preserve U.S. leadership in technology and in the application of the technology for the benefit of the Nation. The communications program seeks to work with the U.S. space communications industry to understand their needs and address those needs systematically in a strategic way. The implementation of this program based on the Office of Advanced Concepts and Technology (OACT) strategic plan will help retain U.S. leadership in the space communications industry and strengthen the industry's competitive position in the global marketplace.

The Space Communications program is comprised of four major program elements. Near Earth communications research explores radio frequency (RF), digital, and mobil communications systems technologies in support of the commercial space communications industry and the needs of NASA's Mission to Planet Earth. The deep space communications element develops technologies primarily to meet the needs of special NASA missions which are not supported by near Earth communications, including planetary exploration and astrophysics. Space terrestrial hybrid systems investigates the space communications portion of hybrid satellite/terrestrial systems such as will be utilized by the National Information Infrastructure. The applications experiments program element supports the Advanced Communications Technology Satellite (ACTS) experiments program, which includes operation of the ACTS spacecraft and its associated ground network and experiment development. This element also supports technology demonstrations of new space communications systems and services.

The near Earth communications systems element analyzes the space communications needs of both the commercial and government sector and manages a technology development program to meet those needs. The technology

areas of interest are high rate and capacity RF systems, optical systems, digital communications systems, mobile satellite communications systems and search and rescue communications systems. NASA will also continue its work in the study and mitigation of propagation effects at various frequencies. The program includes participation in national and international bodies that develop standards and allocate orbit/spectrum. The program provides for experts to support NASA and other government agencies such as the National Telecommunications and Information Administration and the Federal Communications Commission. It also provides technical support to regulatory agencies by developing modeling techniques and strategies for optimal utilization of spectrum and orbit resources. In FY 1993, the development of the first ACTS mobile terminal (AMT) was completed and completion of the development and testing of the second AMT is planned in FY 1994. These terminals are being used extensively in the ACTS experiments program. Additionally, FY 1994 plans include using the mobile terminal hardware, in conjunction with a Monolithic Microwave Integrated Circuits (MMIC) phase array antenna (to be completed in FY 1994) in the demonstration of the first ACTS aeronautics experiment.

The deep space communications systems element includes analysis of the needs for deep space communications by the scientific research community. This community conducts planetary science, space exploration and astrophysics-related missions. The rigors of science requirements and unique mission needs result in technology requirements that cannot be met by commercial communications technology. These requirements are the focus of deep space communications research by the OACT communications program. In FY 1994, the first very high power laser for deep space optical communications is being demonstrated in the laboratory. This will open up new possibilities for more efficient system design for optical communications for deep space applications.

The space terrestrial hybrid systems element is directed toward the incorporation of satellite communication links into the National Information Infrastructure, which will result in significant interaction between terrestrial fiber and wireless communications systems and space communication systems. For maximum effectiveness, the National network should establish communication paths for individual interconnections using whatever combination of communication links will be most efficient, with the actual choice of the links being transparent to the user, even though the transmission characteristics of the links may be quite different. This element analyses the interaction of these components in the overall system, identifying and developing structures and technologies that support hybrid operation. In parallel with this effort is the development of standards and protocols that allow efficient and seamless transport of information between terrestrial and satellite systems.

The applications experiments near-term central focus is the ACTS spacecraft which was launched in September 1993. ACTS will operate from the fall of 1993 to the fall of 1995, with the possibility of continued operations for two more years. Experimenters from industry, academia, and government will demonstrate the operation of several new communications technologies and the application of these technologies to create new classes of communications service. A total of 78 experiments have been approved so far. The ACTS program

will help the U.S. maintain its leadership in the communications satellite market by the development and flight verification of advanced technologies that will enhance the capability of communications satellites. The key ACTS technologies include high effective isotropic radiated power; fast-hopping multiple antenna beam; on-board message switching; Ka-band components; and dynamic rain fade compensation techniques. The U.S. user community, consisting of private sector organizations and other government agencies, will develop and execute experiments that will test and evaluate the ACTS technologies under various applications scenarios. Fiscal Year 1994 is the first year of the ACTS experiments program and emphasizes applications experiments in the areas of education, medicine, business networks and mobile communications using the AMT terminals.

Opportunities for new service and technology demonstrations will also be sought out for joint NASA/industry experiments using satellites of opportunity operating at other RF bands. Such experiments can provide program partners with an opportunity for early verification of their communications systems as well as early service demonstration to the public.

Based on the realization that government support is needed to ensure the survival of a U.S. laser communication (lasercomm) capability, major corporations have formed a consortium to conduct a lasercomm readiness demonstration in the 1997 timeframe. The demonstration includes a low-Earth orbiting spacecraft, an aircraft and a ground terminal, with a goal of 1 GBPS data transfer. It will demonstrate the viability of high data rate transceivers, as well as the acquisition, pointing and tracking needed to achieve connectivity between dynamic terminals. These application-oriented tasks will require significant resources. It is anticipated that they will be carried out using both NASA and non-NASA funding, with significant contributions from industry. A Phase A feasibility study will be initiated in FY 1994 in laser communications in preparation for a potential future flight experiment.

BASIS OF FY 1995 ESTIMATE

The near Earth communications program will support system analysis and application studies, and applied research and advanced development in the areas of high rate RF and digital communications, mobile and personal satellite systems, and search and rescue. The high rate capability radio frequency area will perform research on phased array antenna technology and on high performance electron beam technology for advanced satellite systems. The high rate digital technology area will emphasize research on modulation, coding, and switching up to one gigabit per second. The first aeronautical Ka-Band mobile communication terminal will be demonstrated in joint experiments with ACTS. Two mobile aeronautical terminals operating at Ka-Band frequencies are being built for FY 1995 demonstration of video signal transmission to/from aircraft cabin to/from the ground via ACTS. Propagation and spectrum utilization studies will support the development of technical justification for standards and regulatory decisions at the national and international level. The program will support research and technology development leading to new or

additional applications or capabilities in search and rescue in support of the National Oceanic and Atmospheric Administration's operational program.

The deep space communications activities will include analysis of communications requirements for NASA missions which cannot be satisfied with commercially available equipment, with special emphasis on small spacecraft. The operation of an optical wavelength communication system suitable for deep space communications will be demonstrated.

The space terrestrial hybrid systems effort will be directed toward developing systems to analyze and manage the operation of hybrid systems, largely in collaborative efforts between the University of Maryland CCDS and TRW, Hughes, and Loral. It is expected that the market survey and the initial system design for the Hughes spaceway system will be completed. Work will also continue with the committees and working groups which are developing new communications system standards and protocols to ensure that they will accommodate satellite links.

The applications experiments centerpiece is the ACTS satellite and ACTS experiments. In FY 1995, the second year of ACTS experiments, some of the most advanced satellite communications systems will be demonstrated. The most important demonstration is the high data rate (HDR) communications system that will demonstrate communication at the same rate as fiber optics links and shows that satellites can complement and work together with fiber optic systems. This will be very important because it will demonstrate that satellites can play a unique role in the National Information Infrastructure. Communication via ACTS at 600 MBPS and above will be demonstrated during FY 1995. Additionally, connecting the NASA supercomputers will be demonstrated as one of the HDR experiments. Another area of great importance will be the broad-band aeronautical experiment, which will demonstrate a video signal transmission between the aircraft cabin and the ground via ACTS.

In FY 1995, funding has been reduced in the Near Earth Communications Systems and Applications Experiments (ACTS) program. This reduction will reduce NASA Research Announcement's to support industry in technology development in the areas of radio frequency and digtal systems. The reduction in the Applications Experiments (ACTS) program reflects the completion of the development of the High Data Rate (HDR) and T1-VSAT terminals that will be used for ACTS experiments.

BASIS OF FY 1995 FUNDING REQUIREMENT

SPACE PROCESSING

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Materials processing	17,400	10,400	11,600
Biotechnology	14,500	6,100	7,600
Total	31,900	16,500	19,200

OBJECTIVES AND STATUS

The objective of Space Processing is to support U. S. private sector investment and involvement in commercially-driven space-based research and terrestrial application in materials processing and biotechnology. This objective is accomplished through experiments which use the unique environment of space - microgravity, the vacuum of space, thermal range, etc.

The intent of materials processing commercial application discipline is to aid in developing the next generation super and semiconductors, special coatings and composites, polymers, alloys and new catalytic materials.

Experiment payloads within the materials processing discipline address both space-based and terrestrial initiatives. Some space-based experiments are conducted to develop materials capable of withstanding the environment of low-Earth orbit and to monitor changes in atomic oxygen. The Wake Shield Facility (WSF) free-flyer will be used to manufacture in the ultra vacuum of space improved semiconductors for next generation electronics. The improved sintering project will develop stronger, lighter and more durable bearings and cutting tools for high stress environments. The investment casting activity will use the thermal range achieved in microgravity to develop modeling parameters for improved metal and alloy casting procedures and equipment, having the potential for significant cost savings in a multi-billion dollar industry. Electro-deposition research will focus on the development of higher quality industrial metals and alloys along with prosthetic implant improvements.

Highlights include efforts by a Center for the Commercial Development of Space (CCDS), the Consortium for Materials Development in Space (CMDS), to develop a technique to coat titanium or alloys with hydroxyapatite, which is identical in composition to the material making up teeth and bones. This has significant potential for the medical community in application of this technology for improved prosthetic devices. The CMDS and an aerospace firm are negotiating licensing agreements which have space technology

application but would also be used in the medical community, as noted above. In a separate achievement, another CCDS, the Space Vacuum Expitacy Center (SVEC) applied for a patent in 1993 for a next generation solar cell for power generation modules which are cheaper per watt than existing generators.

The materials processing CCDS base grants funding provides the institutional support for two commercial research centers: the Consortium for Materials Development in Space and the Space Vacuum Expitaxy Center.

The special studies and analyses budget provides for special analyses of emergent market trends for technical projects developed within the Space Processing Division, as well as database analysis and support.

The intent of the biotechnology commercial applications discipline is to aid the pharmaceutical and biomedical communities in developing new products, services and markets, including next generation drugs for treating disease.

Flight hardware supported by this program element, such as the Plant Module for Autonomous Space Support (PMASS), Bio-processing Laboratory (BPL) and Materials Dispersion Apparatus (MDA), continue to greatly expand experiment activities in space under controlled environments. Through the attributes of the microgravity environment, prior experiments in crystal growth techniques and drug structure analyses will be used towards development of new drug combinations, based on the clarity and size of crystals first developed in space.

Highlights of recent achievements include development by a CCDS spin-off firm (BioCryst) of novel drugs (five patents generated) for treating cancer and autoimmune disease. In addition, the Center for Macromolecular Crystallography in collaboration with a leading private research institute is leading efforts in the development of new lymphokines (proteins which regulate the immune system and are used to treat viral diseases). Another highlight is the partnership between the Center for BioServe Space Technologies (BioServe) and Chiron, a Bioserve affiliate holding the patent for the only Food and Drug Administration (FDA) approved drug currently available to treat kidney cancer. BioServe and Chiron will fly this drug in 1994 to test its ability to alleviate the immune suppression which occurs in space. This flight activity has significant terrestrial application in maintaining an active immune system to benefit patients.

The biotechnology CCDS base grant funding element provides institutional support for three commercial research centers in biotechnology: Center for Macromolecular Crystallography, at the University of Alabama/Birmingham; Wisconsin Center for Space Automation and Robotics of Wisconsin; and the Center for Bioserve Space Technologies.

BASIS OF FY 1995 ESTIMATE

The major goal of the Space Processing program for FY 1995 is to prioritize key commercial space initiatives and increase the emphasis on focused program objectives in materials processing and biotechnology on those technologies having the most potential for near-, mid- and long-term technical and commercial application success.

Close collaboration will take place with the materials and biotechnology researchers to foster commercial as well as government use for the experiment carriers developed under the auspices of the Space Processing Division (BPL, MDA, PMASS, the Wake Shield itself, etc.). We will continue to foster the progress made in the biotechnology community transitioning drug research to patent protection and eventually approved manufacture of new drugs. We will also explore cooperative agreements where applicable, in order to maintain program flexibility at a time of greatly constrained resources.

As a result of FY 1994 phase-out of several CCDS, the breadth of commercial materials processing activities will be reduced and prioritized.

It is anticipated that there will be commercial validation of advanced casting technologies during FY 1995 (Auburn CCDS) as a result of commercial research associated with low cost, high quality thin wall castings of alloys; this casting technology will utilize automated manufacturing processes. There will also be commercial processing techniques for epitaxial thin film growth developed as a key milestone in commercial transition of thin film growth in microgravity (SVEC CCDS). Licensing arrangements will be developed between the CMDS and the private sector for hydroxyapatite coating/electrodeposition coating processes.

Materials processing CCDS base grants funding will continue to provide institutional support for two commercial research centers: the Consortium for Materials Development in Space and the Space Vacuum Expitaxy Center.

Under materials processing special studies and analyses, special analyses will be done of emerging market trends for technical projects developed within the Space Processing Division, as well as database analysis and support.

As a result of FY 1994 phase-out of several CCDS, the breadth of commercial biotechnology activities will be reduced and prioritized.

In respect to biotechnology commercial applications, FY 1995 will see continued commercialization of drugs whose structural design was greatly enhanced through the biotechnology microgravity of space.

It is anticipated that a CCDS spin-off firm (BioCryst) in collaboration with the Center for Macromolecular Crystallography will continue towards commercial drug development of specific drugs developed through prior flight research activities and licensing agreements with major pharmaceutical firms.

In collaboration with a major pharmaceutical firm, there will be clinical tests in 1995 of Gamma interferon protein crystals grown from prior space flight activities. There will be commercial development, in partnership between a CCDS and a major pharmaceutical firm, of malic enzyme inhibitors.

Biotechnology CCDS base grants funding will continue to provide institutional support for three commercial research centers in biotechnology: Center for Macromolecular Crystallography, Wisconsin Center for Space Automation and Robotics of Wisconsin; and the Center for Bioserve Space Technologies.

BASIS OF FY 1995 FUNDING REQUIREMENT

NASA TECHNOLOGY TRANSFER

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Technology dissemination	5,700	6,100	8,800
National network	9,700	9,900	8,600
Regional technology transfer centers (RTTC)	(6,800)	(7,000)	(7,000)
Commercial applications	7,600	6,200	7,400
Civil systems	6,500	5,600	12,000
AdaNET	(2,100)	(2,200)	(2,200)
National technology transfer center (NTCC)	(4,400)	(3,400)	(9,800)
Total	29,500	27,800	36,800

OBJECTIVES AND STATUS

The NASA Technology Transfer program is designed to transfer and apply aerospace technology resulting from NASA's research and development (R&D) efforts to the private sector in order to enhance the productivity and competitiveness of U.S. companies in the international marketplace. To accomplish this objective, NASA operates a number of technology transfer mechanisms designed to provide private companies and other government agencies with timely access to useful NASA derived technologies with commercial potential. In the past, aerospace technologies have been beneficial in improving medical treatments and procedures, rehabilitation, transportation, and safety. The specific goals of this program are:

- to accelerate and facilitate the effective application of new NASA technology into the commercial sector;

- to encourage multiple secondary uses of NASA technology in industry, education and government, and/or develop dual use technologies in partnership with private industry which will address the technological needs of both NASA and industry; and

- to develop applications of NASA's aerospace technology, including its unique facilities, to address priority non-aerospace needs of the private and public sectors.

BASIS OF FY 1995 ESTIMATE

Funding for the Field Center technology transfer offices will be enhanced to provide for increased outreach capability to conduct economic development activities; increased capability to negotiate cooperative agreements with commercial firms; and increased ability to conduct in-house new technology evaluations and manage the task of maintaining and reporting NASA technology information in an efficient manner. Preparation of Tech Briefs magazine layouts and related materials will continue. The Center for Aerospace Information will also continue to provide support by responding to general or specific inquires from public and private sources for information concerning NASA technological developments and other technology transfer program products and services.

The Regional Technology Transfer Centers (RTTC) will continue to provide enhanced linkages between the NASA and other Federal agency technology transfer offices and commercial firms or state and local economic development agencies. The Office of Advanced Concepts and Technology (OACT) will also provide funding for other critical elements of the technology transfer program, such as the Technology Commercialization Centers established in FY 1993 at the Johnson Space Center and Ames Research Center, and new initiatives in commercialization of NASA technology.

A small core of technology application projects conducted in partnership with commercial firms or other government agencies will continue to be funded. Only those projects considered to have a high probability for commercial success (as determined through a market analysis) and with commercial or other agency support, either through cost sharing or provision of "in kind services", will be funded. The Joint Sponsored Research program will continue to accelerate the development of dual-use NASA mission technology that is also of value to the commercial sector.

The AdaNET software repository and pilot project to determine the feasibility of using reusable software components to satisfy complex software development needs will continue as planned. The National Technology Transfer Center (NTTC) will continue to facilitate the transfer of Federal technology (both NASA and other agencies) through operation of a national gateway/clearinghouse that links "technology inquirers" with Federal laboratories; development of teaming arrangements between Federal laboratories and industry as well as state and local governments; and development of technology transfer training programs for Federal managers. In addition, the NTTC will begin to develop plans to improve NASA technology transfer performance and supporting processes through development of additional training programs, investigation into new and innovative methods for industry to access NASA new technology information, and examination of additional outreach/extension possibilities.

BASIS OF FY 1995 FUNDING REQUIREMENT

ADVANCED SMALLSAT TECHNOLOGY

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Advanced smallsat technology....................	--	12,500	47,900

OBJECTIVES AND STATUS

This FY 1994 new initiative has as its principal objective to revolutionize the way NASA does business in designing, building, launching, and operating small spacecraft for scientific missions and commercial activities in space. A solicitation for proposals in February 1994 will precipitate the formation of Integrated Product Development (IPD) Teams to bid two technology demonstration satellites to be conceived, designed, built, qualified, and launched in two and three years, respectively. The IPD Teams will have unprecedented responsibility for the utilization of commercial practices and standards and the establishment of metrics for measuring success. The degree of success or failure will be determined during the one-year or more operational phase on-orbit.

Contracts for at least two IPD Teams will be established in approximately May 1994 after an abbreviated selection process. NASA Headquarters representatives will be IPD Team members to facilitate fast, minimum-paper, decision-making at the Team site. Elaborate government reviews with large numbers of government bureaucrats will NOT be allowed. Reviews with essential government managers and executives will be held at IPD Team locations. An important product of this activity, in addition to the actual technologies that are demonstrated, is documentation of this radical IPD process. The process and lessons learned will have far-reaching implications for future NASA missions and commercialization of space.

BASIS OF FY 1995 ESTIMATE

Fiscal Year 1995 is a crucial funding year for the program. Approximately 50 percent of the total program funding is required to meet the ambitious schedule of contract-to-launch in 24- and 36-months, respectively, for the two missions. Major hardware commitments for the spacecraft buses, payloads, and launch vehicles will be made. Missions operations and control will be defined; integration of the subsystems into the overall spacecraft bus design will occur; data system will be defined for the information and power management system; low mass instrumentations will be incorporated into the instruments and sensors payloads; and non-aerospace commercial applications will be initiated.

BASIS OF FY 1995 FUNDING REQUIREMENT

INDUSTRY TECHNOLOGY PROGRAM

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Industry technology program....................	--	19,700	18,900

OBJECTIVES AND STATUS

The objective of the Industry Technology program is to significantly advance aerospace technologies in U.S. industry which have a high probability of leading to commercial products and applications, or to non-aerospace industry applications, and which may be important in NASA applications. To accomplish this objective, the program will: (1) develop pre-competitive technologies and novel applications, supporting high-risk and high-payoff research and development (R&D); (2) focus on aerospace concepts and technologies with strong potential for commercial benefits (where appropriate, these may include government or non-aerospace commercial applications); (3) work with industry in all aspects of the program - including program formulation and planning, industry-led project planning and execution, and providing government technology to support projects as requested; and (4) create industry-led consortia to implement projects where such teams can enhance technology development and increase the probability of commercial application - potentially including organizations that are not part of the traditional Federal contracting base as well as potential roles for universities and other organizations.

The Industry Technology program, which will be an important component in NASA's overall support to the Administration's technology policy, is being initiated in FY 1994. The FY 1994 program will create a number of individual technology development and application projects. Projects will focus on R&D in pre-competitive aerospace technologies and novel applications, supporting high-risk and high-payoff opportunities that demonstrate strong potential for commercial benefits. They may exhibit a mix of technology development and transfer activities, but will emphasize applications, while still achieving significant technical advancements. During FY 1994, the Industry Technology program will likely create ten to fifteen or more cooperative agreements.

BASIS OF FY 1995 ESTIMATE

The FY 1995 Industry Technology program will create a number of additional technology development and application projects. As in FY 1994, projects will focus on R&D in pre-competitive aerospace technologies and novel applications, supporting high-risk and high-payoff opportunities which demonstrate strong potential for commercial benefits. In addition, the FY 1995 program is planned to create an additional ten

to fifteen or more cooperative agreements. The program will include the goal of 50 percent industry cost sharing in each of the projects.

BASIS OF FY 1995 FUNDING REQUIREMENT

SMALL BUSINESS INNOVATION RESEARCH

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995
Small business innovation research (SBIR)			
Phase I awards	(29,478)	(17,197)	28,000
Phase II awards	(69,347)	(90,717)	90,000
SBIR Subtotal	(98,825)	(107,914)	118,000
Small business technology transfer pilot program (STTR)			
Phase I awards	--	(3,597)	1,400
Phase II awards	--	--	4,500
STTR Subtotal	--	(3,597)	5,900
SBIR/STTR Total	(98,825)	(111,511)	123,900

OBJECTIVES AND STATUS

The NASA Small Business Innovation Research (SBIR) program is designed to obtain quality research and development from small businesses throughout the U.S. that satisfy not only the mission needs of NASA for innovative technology, but also those of the commercial sector. The primary goal is thus twofold: to meet NASA's need for innovative technology and to fully commercialize this technology through the small business community. The Small Business Technology Transfer Pilot (STTR) program, established in FY 1994 by Congress, P.L. 102-564, as an adjunct to the SBIR program, is a three year pilot program intended to increase cooperative, broad research efforts in critical technology areas with small businesses and research institutions with a goal of eventual commercial application of the technologies.

BASIS OF FY 1995 ESTIMATE

The FY 1995 level of funding will support a wide variety of research efforts at small companies throughout the U.S. It is expected that approximately 380 Phase I contracts will be awarded and approximately 180 Phase II contracts. The Phase I awards are intended to determine the technical and commercial feasibility of the proposals. The Phase II awards further develop those Phase I proposals which have demonstrated scientific and technical worth and commercial potential during Phase I development. Additional efforts will

be undertaken to increase the commercialization of SBIR derived technology, to improve the solicitation process to encourage submission of increasingly innovative proposals, and to outreach to more women-owned and socially and economically disadvantaged small businesses.

In FY 1995, the STTR initiated in FY 1994 will continue and Phase II awards will be initiated for those Phase I contracts initiated in FY 1994 which demonstrated the highest scientific, technical and commercial value at the conclusion of the Phase I process. In addition to the new Phase II STTR awards, additional STTR Phase I proposals will be funded to investigate new proposals for research by the small business community.

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1995 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

LAUNCH SERVICES

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Small	25,272	16,800	31,400
Medium	61,451	93,500	116,200
Intermediate	41,100	63,200	70,200
Large	5,278	86,400	91,300
Upper stages	47,700	43,600	31,800
Expandable launch vehicles (ELV) upgrades	--	10,000	--
Total	180,801	313,500	340,900
Distribution of Program Amount by Installation			
Kennedy Space Center	12,700	12,000	12,400
Marshall Space Flight Center	46,957	43,600	31,400
Lewis Research Center	46,178	148,000	156,400
Goddard Space Flight Center	71,934	92,400	114,200
Jet Propulsion Laboratory	200	--	--
Headquarters	2,832	17,500	26,500
Total	180,801	313,500	340,900

OBJECTIVES AND STATUS

The Launch Services program provides a mixed fleet capability which, in conjunction with the Space Shuttle, satisfies NASA payload requirements. Payloads are assigned for launch on Expendable Launch Vehicles (ELVs) consistent with Shuttle use criteria established in NASA's FY 1991 Authorization Act and the Launch Services Purchase Act of 1990.

With the exception of launch services provided for the Cassini mission and some launches procured for the National Oceanic and Atmospheric Administration (NOAA) under a reimbursable agreement, all ELV launch services are competitively procured from the private sector to launch civil government payloads in three performance classes:

(a) Small class -- payloads up to 1,000 lbs. in low Earth orbit
(b) Medium class -- payloads up to 11,000 lbs. in low Earth orbit
(c) Intermediate class -- payloads up to 20,000 lbs. in low Earth orbit

The Small Expendable Launch Vehicle (SELV) program is managed by the Goddard Space Flight Center (GSFC). In September 1991, a contract with Orbital Sciences Corporation (OSC) was awarded to provide a minimum of seven (7) Small Expendable Launch Vehicle (SELV) services using the Pegasus vehicle. The first two of these vehicles are currently being prepared for launch of the Total Ozone Mapping Spectrometer (TOMS) mission in May 1994 and the Fast Auroral Snapshot Explorer (FAST) mission in August 1994 from the Western Test Range (WTR) launch complex at Vandenburg Air Force Base (VAFB). Preparations are also underway for the Submillimeter Wave Astronomy Satellite (SWAS) mission launch in June 1995.

The Medium Expendable Launch Vehicle (MELV) program is also managed by the GSFC. In November 1990, a contract with McDonnell-Douglas (MDAC) was signed to provide a minimum of three launch services using the Delta II vehicle. Preparations are currently underway for launches of the Global Geospace Science (GGS) missions, Wind and Polar, in April and June 1994. However, these launch dates are under review due to spacecraft development delays. Initial procurements are also planned for FY 1994 in support of the Advanced Composition Explorer (ACE) launch in August 1997 as well as the Near-Earth Asteroid Rendezvous (NEAR) and Mars Environmental Survey (MESUR) Pathfinder launches in February and December 1996, respectively. Although no funding was requested in the FY 1994 budget, funding is also required in FY 1994 to initiate procurement of a Delta II launch vehicle in support of a Mars Orbiter launch in October 1996. Identification of FY 1994 funds required to support this mission are currently under review.

The Intermediate Expendable Launch Vehicles (IELVs) program is managed by the Lewis Research Center (LeRC). In September 1993, a competitive request for proposals was released to provide launch services for future missions. Contractor proposals were received in December, and final selection is anticipated in the next few months. Potential missions include the Geostationary Operational Environmental Satellite (GOES) series.

the Earth Observing System (EOS) AM/PM series, the advanced Tracking and Data Relay (TDRS) series, and potentially some international cooperative missions. Funds are provided in FY 1994 for the first of these new vehicles -- the EOS AM-1 vehicle scheduled for launch in June 1998. Payload testing and integration activities are also currently underway to support the Solar and Heliospheric Observatory (SOHO) mission launch in July 1995.

The Large class ELV (LELV) program is managed by the Lewis Research Center (LeRC). This program supports a single launch vehicle -- the Titan IV/Centaur which is being provided for the October 1997 launch of Cassini by the U.S. Air Force (USAF). Large performance class missions with payloads over 30,000 lbs. to Low Earth orbit (LEO) must be acquired through the Department of Defense (DoD) since no commercially provided launch services are currently available for this performance class. Mission integration activities for these missions will be performed via a separate contract with Martin Marietta, and initiation of this contract will begin in FY 1994. Initial design and procurement activities for the core vehicle are also underway under the USAF contract.

The Upper Stages program provides propulsion for NASA payloads launched aboard the Space Shuttle which require a higher energy orbit. The USAF is currently providing an Inertial Upper Stage (IUS) to support the TDRS-G mission scheduled for launch in July 1995. A commercial upper stage will also be procured for the Advanced X-ray Astrophysics Facility (AXAF-I) mission launch in September 1998. A competitive request for proposals for the AXAF-I upper stage was released in November 1993, and final contract award is scheduled for May 1994.

The ELV Upgrades program is designed to infuse mature technologies into the U.S. commercial ELV fleet, reduce cost, increase reliability, and increase ELV industry competitiveness. This initiative has been collaboratively designed with domestic ELV industry contractors and the Commercial Space Transportation Advisory Committee (COMSTAC), which has identified a series of candidate projects for the current domestic ELV fleet. Included in the FY 1994 budget is $10.0 million to support the initiation of selected technology improvements which can be applied through existing launch services contracts. Due to funding constraints, no funding is provided in FY 1995 and beyond. Plans for use of FY 1994 funding are therefore on hold pending resolution of outstanding budget issues. The Agency will provide additional information on the application of these funds in a subsequent operating plan.

BASIS OF FY 1995 ESTIMATE

The FY 1995 SELV funding supports the launch of the Satellite de Applicaciones Cientificas-B (SAC-B)/High Energy Transient Experiment (HETE) and the Submillimeter Wave Astronomy Satellite (SWAS) launches in March and June 1995, respectively. Initial funding is also included for the next Small Explorer (SMEX-4) tentatively planned for launch in 1997. The FY 1995 MELV funding supports the Radarsat cooperative mission with Canada in December 1994 and the X-ray Timing Explorer (XTE) launch in August 1995. Initial funding is

also included for the NEAR mission in February 1996, the MESUR Pathfinder mission in December 1996, and the Advanced Composition Explorer (ACE) mission in August 1997. Funding is also provided for the new Mars Orbiter mission, which requires a Delta-class launch in October 1996.

The FY 1995 IELV funds support final preparations and launch of the SOHO mission in July 1995. Funding is also included for procurement of launch services for the EOS AM-1 scheduled for launch in June 1998. The LELV funding supports ongoing fabrication of the Titan IV/Centaur launch vehicle for the Cassini mission, scheduled for an October 1997 launch. The Upper Stage budget supports the TDRS-G launch on an IUS from the Space Shuttle in July 1995. Initial funding is also included for the acquisition of a commercially provided upper stage for the AXAF-I scheduled for launch in September 1998.

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1995 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE COMMUNICATIONS

MISSION COMMUNICATION SERVICES

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1993	FY 1994 (Thousands of dollars)	FY 1995	Page Number
Ground network	306,601	311,300	273,400	SAT 7-4
Mission control and data systems	156,914	205,600	175,800	SAT 7-10
Space network customer service	27,900	30,000	32,000	SAT 7-15
Advanced technology	23,273	24,600	--	SAT 7-17
Construction of facilities	31,800	17,600	--	SAT 7-18
Total	546,488	589,100	481,200	

Distribution of Program Amount by Installation

	FY 1993	FY 1994	FY 1995
Lewis Research Center	--	930	1,500
Ames Research Center	18,463	14,300	18,300
Goddard Space Flight Center	276,612	324,816	260,800
Jet Propulsion Laboratory	221,035	220,006	179,300
Headquarters (including foreign contracts)	30,378	29,048	21,300
Total	546,488	589,100	481,200

OBJECTIVES AND JUSTIFICATION

The Mission Communication Services (MCS) program provides tracking, telemetry, command and data acquisition for NASA space science, Earth science, and aeronautics systems, and supports Space Transportation System (STS) launch and landing operations through the use of common ground network systems primarily dedicated to science applications. Support is also provided to international flight programs and for the needs of other domestic users. Development of new system capabilities, ongoing maintenance and refurbishment of existing facilities and equipments, and mission and space flight operations planning activities are also funded under this program.

Beginning in FY 1995, funding for these activities is requested under the NASA appropriation for Science, Aeronautics and Technology, so as to link these activities more directly with the Agency programs which constitute the principal users of these facilities and programs. As with other NASA programs, discrete, program-direct Construction of Facilities projects are now included in this account. The FY 1993 and FY 1994 values reflect the restatement of accounts consistent with this change.

These capabilities are provided to meet the requirements of NASA's near-Earth orbiting astronomy, Earth science, and space plasma physics space flight missions; NASA's planetary exploration missions; other science programs conducted using NASA's scientific research aircraft, sounding rockets and balloons; and test flight programs conducted in support of NASA's aeronautical research and development program. These facilities are also used to provide tracking for the STS during its launch and landing sequences. These funds support the establishment, advancement, and conduct of NASA's ability to determine the position and trajectory of vehicles during space flight and operation; to acquire real-time health and safety data for spacecraft and launch vehicle systems during flight; to uplink spacecraft and instrument commands from ground facilities to orbiting or deep space traveling spacecraft; and to download the scientific data obtained by on-board instruments and sensor systems.

Additional capabilities funded under this program provide for the planning and implementation of future missions; for the acquisition and processing of launch vehicle data obtained during launch sequences; for the operation of Payload Operations Control Centers (POCC) at the Goddard Space Flight Center (GSFC) which provide real-time management, planning and operation of spacecraft flight systems and their scientific observations; and for the planning and implementation of orbital and maneuverable trajectories needed to sustain the health and safety of robotic spacecraft systems or to conduct scientific data-gathering.

Similar capabilities provided for planetary exploration missions are funded by NASA under other program elements outside of the MCS program. Access by NASA users and by all external users to the Space Network via the Network Control Center (NCC) located at GSFC is also funded under this program.

Finally, funding is provided for NASA management of its access to specific communications frequencies in order to conduct space-based and ground-based radio transmissions. Members of the Office of Space Communications participate in national and international exchanges of information and as representatives to governing boards and other bodies in sponsorship of NASA's interests and of the interests of other users of NASA's communications facilities and systems.

BASIS OF FY 1995 FUNDING REQUIREMENT

GROUND NETWORK

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Deep space network systems implementation	78,175	97,500	86,800
Deep space network operations	115,496	102,900	106,100
Spaceflight tracking and data network systems implementation	5,526	3,400	1,900
Spaceflight tracking and data network operations	62,396	56,400	32,200
Aeronautics, balloons, and sounding rockets systems implementation	21,386	26,300	20,000
Aeronautics, balloons, and sounding rockets operations	23,622	24,800	26,400
Total	306,601	311,300	273,400

OBJECTIVES AND STATUS

NASA's Ground Network program provides direct support to the missions flown under NASA's Earth orbiting, planetary, aeronautics test, and suborbital programs. In addition, launch and landing range support is provided to the Space Transportation System (STS) from several of NASA's ground network facilities. The Ground Network program funding provides the operation and maintenance of the worldwide tracking facilities. Implementation funds are used for the design, development, and implementation of ground network hardware and software subsystems to better service NASA flight missions.

Due to fiscal constraints upon the entire NASA program in FY 1995, the Ground Network program is planning to implement lower-cost methods of providing operational services to NASA's flight programs and projects, including greater use of advanced technologies, reduction of overhead costs, and reduction of the scope and quality of services. Specific actions include elimination of some planned 34-meter Beam Wave Guide Electronics systems and reduction of orbital support provided by the Merritt Island and Bermuda tracking facilities. Completion of the Nimbus-7 and Magellan missions will provide relief from some support requirements, as well, as will savings accruing from loss of the Mars Observer spacecraft. NASA's Dakar station is scheduled to be closed in the spring of 1994 and the UHF astronaut voice communications

capability will be relocated to a nearby Senegal Earth station. Other specific actions await clarification upon the receipt of responses from NASA's contractor, engineering, and science communities.

The Deep Space Network (DSN), operated by the Jet Propulsion Laboratory (JPL), Pasadena, California, provides telecommunications for NASA's planetary and solar system exploration missions as well as for Earth orbiting missions, which can not be accessed by the Tracking and Data Relay Satellite System (TDRSS). The DSN receives spacecraft telemetry and download of scientific data and transmits command, control and navigation signals to a variety of spacecraft from distances relatively near the Earth to those as great as 8 billion kilometers from the Earth. Three DSN antenna and communications support complexes are maintained at Goldstone, California; Canberra, Australia; and Madrid, Spain. The central network control center is located at the JPL in Pasadena, California.

The systems required to perform tracking and data acquisition of spacecraft at the limits of the solar system are highly specialized and include large aperture antennas which can receive extremely weak radio signals. These antennas use ultra-sensitive receivers and powerful transmitters. Extremely stable time standards are also required for precise navigation of distant spacecraft. Advanced data handling systems are required at both the Network Operations Control Center (NOCC) located at the JPL and the Deep Space Communications Complexes located in California, Spain, and Australia. Funds contained in the DSN Systems Implementation program are used to support initiatives to enhance communication with spacecraft at these ever greater distances from the Earth. Other enhancements are required to provide enhanced precision of navigation needed for highly accurate and stable spacecraft pointing, science data acquisition targeting, and probe delivery. These capabilities are fundamental to some of NASA's future deep space missions, such as Cassini.

The DSN Operations program provides for ongoing operation of the three DSN antenna sites and of the JPL NOCC. Missions currently supported are the deep space Ulysses, Voyager 1 and 2, Pioneer 10 and 11 missions; the Magellan and Galileo planetary missions; the Small Explorer Mission Solar Anomalous, and Magnetospheric Particle Explorer (SAMPEX); and the international Astro-D, Roentgen Satellite (ROSAT), and Geotail missions. Magellan was recently lowered in orbit via aerobraking maneuvers to perform gravity field studies. Its operation is scheduled to end in FY 1994.

New requirements for DSN services include a 1994 launch and operation of the Infrared Space Observatory (ISO), the Total Ozone Mapping Spectrometer Earth Probe (TOMS EP), the Fast Auroral Snapshot Explorer (FAST), and the Polar and Wind spacecraft of the Global Geospace Science (GGS) program. The DSN will also be used to collaborate with the Ballistic Missile Defense Organization in two space flight missions that are testing lightweight instruments and sensors. Clementine, to be launched in January 1994, is to explore the moon's polar regions before it travels on to an August flyby of the asteroid Geographos. The Space Technology Research Vehicle (STRV) is scheduled for launch in February 1994 for a year long Earth orbiting mission. 1995 launch and operation of the Submillimeter Wave Astronomy Satellite (SWAS), and the

international Solar Observatory for Heliospheric Observation will add to these requirements. Finally, ongoing support for ground-based radar and radio astronomy observations will be provided by the DSN. The network's ultra-sensitive antennas are being used in an attempt to learn more about pulsar high energy sources, quasars, and other interstellar and intergalactic phenomena. Solar system radar is useful in understanding surface characteristics of planets, asteroids, comets, moons, near-Earth asteroids, and ring systems.

The function of the Spaceflight Tracking and Data Network (STDN) is to provide pre-launch, launch, and landing communications required by the STS. The STDN consists of three ground stations located at Bermuda; Merritt Island, Florida; and Dakar, Senegal. The Bermunda and Merritt Island stations are capable of tracking spacecraft, transmitting commands for spacecraft and experiment control, receiving engineering and scientific data from the spacecraft and providing primary and backup voice communications for STS operations and range safety functions for the Eastern Range in coordination with the Wallops Flight Facility (WFF). The Dakar station, which also provided telemetry and voice communication in both S-band and UHF frequencies, has begun to be closed. The S-band voice communication was ended in December 1993, and the NASA facility will be vacated this spring. The UHF voice communication will continue to be provided from a Senegalese government communication facility until December 1995, when all support from Senegal will be terminated. Termination is feasible at that time because of the completion of redundant Space Network ground terminal capability at the White Sands, New Mexico complex. Combined with the DSN, the STDN ground communications stations also provide emergency access to Earth-orbiting scientific spacecraft if they become unable to communicate through the TDRSS Space Network. Efforts are underway to reduce operations and maintenance costs through replacement of obsolete equipment.

The two elements of the Aeronautics, Balloons, and Sounding Rocket (AB&SR) program, Systems Implementation and Operations, provide funding for a wide range of NASA activities, including aeronautical research flight testing; launch vehicle tracking and communication; and support to the aircraft, balloon, and sounding rocket elements of NASA's suborbital research and technology demonstration programs. Tracking and communications support to a limited number of scientific spacecraft is also provided. In addition, tracking and communications support for landings of the STS is provided by this program. Funds are provided to the Ames Research Center (ARC) and to the Goddard Space Flight Center (GSFC) for these purposes.

Primary facilities of the AB&SR program are located at the WFF and the Dryden Flight Research Facility (DFRF). The Western Aeronautical Test Range (WATR) is composed of the DFRF as well as ranges at Moffett Field and Crows Landing. The principal function of the WATR is to provide tracking and communication support for aeronautical research flight testing. The DFRF has the additional responsibility of providing tracking and communications for STS landings along with the DSN facilities at Goldstone. The WATR maintains an aggressive schedule of aeronautics research operations. During FY 1993, WATR operations included 1,553 missions conducted at the three facilities, which are managed by the ARC. The trend continues upward in

FY 1994 with approximately 2,000 aeronautical missions planned. Programs tracked from these ranges included high performance aircraft, advanced technology research aircraft, and complex control systems and powered lift technologies. The WFF, which is managed by the GSFC, also manages a wide range of other NASA facilities. The facility at Wallops Island, Virginia, is used for tracking orbiting scientific spacecraft and for conducting sounding rocket and small meteorological balloon launches. The Wallops Orbital Tracking Station (WOTS) also provides round-the-clock space tracking operations for various spacecraft missions and for the STS. The WFF also manages the operation of several off-site ranges located at the White Sands Missile Range, New Mexico; the Poker Flat Research Range, Fairbanks, Alaska; the National Scientific Balloon Facility, Palestine, Texas, and at Ft. Sumner, New Mexico. Finally, tracking and data acquisition is provided for mobile campaigns of balloon and sounding rocket launches which are conducted at various locations throughout the world.

During FY 1993, WFF operations included sixty-four aeronautics missions, twenty sounding rocket flights, and thirty-four balloon flights. Ninety, forty-eight, and twenty-five flights are planned for each of these activities, respectively, in FY 1994. Aeronautics flight programs in the areas of automatic landing operations using Global Positioning Satellite inputs; aircraft performance using vortex flap technology; the Shuttle Microwave Scanning Beam landing system checkout; WFF Range Surveillance; and Langley lifting body launch abort studies were supported.

The AB&SR Systems Implementation program is directed at assuring reliable service to NASA's research programs. Aeronautical, balloon and sounding rocket research requires specially instrumented ranges as well as mobile stations. These funds are also being used to establish new ground stations facilities in Earth's polar regions for upcoming missions related to NASA's Mission to Planet Earth program. A facility at McMurdo Sound, Antarctica is being developed in cooperation with the National Science Foundation (NSF) to meet the requirements of the joint U.S.-Canada Radarsat mission. This mission will also be supported by the Alaska Synthetic Aperture Radar (SAR) Facility, Fairbanks, Alaska, which is being developed concurrently as the principal U.S. ground station for the international Advanced Earth Observing Satellite (ADEOS) mission.

The AB&SR Operations program supports the operation and maintenance of ground-based tracking instrumentation systems, both fixed and mobile, under the management of the ARC and the GSFC. Tracking, radar, telemetry, data acquisition, data processing, data display, communications, and special purpose optical equipment are located at these disperse facilities.

In FY 1993 and FY 1994, the WOTS will provide tracking operations for the STS, the International Ultraviolet Explorer (IUE), the Interplanetary Monitoring Platform (IMP-8), Meteosat, NOAA-10, TOMS Meteor-3, the ROSAT, and the SAMPEX. Support to the Fast Auroral Snapshot Explorer (FAST) and TOMS Earth Probe missions is also planned to begin upon their launch in 1994.

BASIS OF FY 1995 ESTIMATE

FY 1995 funding for DSN Systems Implementation is intended to support reliability and maintainability initiatives at the DSN sites, to assure the success of the Galileo Low Gain Antenna mission, and to complete a new DSN 11-meter antenna subnet in support of the Russian Radioastron and the Japanese VSOP programs. The FY 1995 budget also provides for multimission improvements needed to accommodate a variety of missions that will be operating in the mid-to-late 1990's including Cassini, the joint U.S.-Canadian Radarsat, the joint U.S.-Japanese ADEOS mission, elements of the International Solar Terrestrial Physics (ISTP) program, the Advanced Composition Explorer (ACE), and the Near Earth Asteroid Rendezvous (NEAR) and Mars Environmental Survey (MESUR) missions. Finally, the Army will transfer two 34-meter Antenna Research System (ARS) antennas to the Goldstone facility in FY 1994. One of these antennas will be modified to support NASA spacecraft communications in FY 1995. Transfer of these antennas will preclude the necessity for future purchases of new antennas which had been planned.

The DSN Operations funding will provide for the maintenance and operation of network facilities and for the support of the sustaining engineering required for continued operation of the network. The DSN will also provide emergency communications to endangered spacecraft and serve as backup to the TDRSS Space Network. Major TDRSS users that have used ground-based emergency communications include the STS, the Hubble Space Telescope (HST), the Compton Gamma Ray Observatory, the Upper Atmospheric Research Satellite (UARS), and TOPEX.

The FY 1995 request for STDN Systems Implementation provides funds to replace obsolete equipment and subsystems required for the STS operations at the Merritt Island, Florida, and Bermuda STDN tracking stations. The reduced request for funds for STDN Operations reflects the discontinuance of centralized management and funding for a logistical supply depot. Beginning in FY 1995, funding for depot logistics will be provided for out of the respective program elements within the Mission Communication Services program where these requirements will compete with funds available to support the NASA scientific user community. Magnetic tape certification and a centralized equipment repair facility will continue to be funded under this program element.

The FY 1995 request for STDN Operations provides for the operation and maintenance of the STDN ground stations and limited tracking services purchased from the Department of Defense (DoD) and the University of Chile. In FY 1995, the STDN will be composed of the Merritt Island and Bermuda stations with a limited UHF voice capability provided from Senegal. The function of these stations will be limited to STS launch and landing support activities.

The AB&SR Systems Implementation program includes funding for support of aeronautical research and scientific experiments using sounding rockets and balloons. This support includes fixed and mobile instrumentation systems, including radar, telemetry, optical, communications, command, and data handling and

processing capabilities. The FY 1994 budget request includes funds to continue to replace and upgrade test and calibration equipment and to refurbish or modify equipment to assure reliable performance. Funds are also included for acquisition of equipment in support of the Radarsat and ADEOS missions and for the automation of the WOTS.

The funding for the AB&SR Operations program supports the operation, maintenance, and technical services needed to provide tracking, data acquisition, and command and control from these disperse fixed and mobile facilities. Funds are included to prepare for Radarsat operations at McMurdo and for the operation and maintenance of the Alaska SAR facility. Funds are also provided for aeronautics research operations and for overhaul of radar systems at the WFF and the DFRF.

BASIS OF FY 1995 FUNDING REQUIREMENT

MISSION CONTROL AND DATA SYSTEMS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Mission control systems	14,241	17,500	14,300
Mission control operations	48,336	52,700	51,000
Data processing systems implementation	29,460	44,400	40,600
Data processing operations	64,877	91,000	69,900
Total	156,914	205,600	175,800

OBJECTIVES AND STATUS

The Mission Control and Data Systems program provides for the development and operation of facilities and systems that are required for mission control and data processing for space flight missions conducted by the Goddard Space Flight Center (GSFC).

In addition to supporting currently operating spacecraft, Mission Control and Data Systems funding provides for the planning and implementation of several new missions soon to be launched. These include the Wind, Polar, Solar and Heliospheric Observatory (SOHO), and Cluster missions of the International Solar Terrestrial Research program; the Fast Auroral Snapshot Explorer (FAST) and Submillimeter Wave Astronomy Satellite (SWAS) Explorer missions; and the Total Ozone Mapping Spectrometer Earth Probe (TOMS EP). The Space Shuttle will carry several Spacelab and attached payloads into orbit this year with data processing preparations nearing completion.

In order to achieve funding reductions faced by NASA programs in FY 1995, the Mission Control and Data Systems program will implement lower cost methods of providing operational services to NASA's flight programs and projects. These methods include use of advanced technology, reducing overhead costs, and reducing the scope or quality of services. The end of operations for the Cosmic Background Explorer (COBE) will also aid in achieving these reductions. Other actions include consolidation the Spacelab Data Processing Facility; phase-out of the operation of Generic Time Data Multiplexing facility; termination of the implementation of Advance On-board System Testbed facility; elimination of some improvements to the Hubble Space Telescope's ground station support; and reduction in Flight Dynamic services for a number of missions. Other specific actions await clarification upon the receipt of responses from NASA's contractor, engineering and science communities.

The mission control function provides support for the planning of scientific observations and implementation of command sequences that are transmitted to the spacecraft. Real-time information is crucial to determine the condition of the spacecraft and payloads and to prepare commands in response to emergencies. Funding for this activity also supports the transformation of spacecraft downlink data into a form usable for spacecraft monitoring in the control centers and for telemetry and scientific data analysis by the scientific investigation teams.

The Mission Control Systems program provides the systems and facilities needed for the command and control of the GSFC's unmanned scientific satellites. Command and control of the spacecraft and on-board experiments are carried out by the respective Payload Operations Control Centers (POCCs) and their auxiliary facilities.

The POCCs are responsible for the receipt, processing, and display of spacecraft engineering data and the generation of commands. Five POCCs currently monitor and control eleven spacecraft. The Extreme Ultraviolet Explorer (EUVE), launched last year, is the last new spacecraft that will be controlled out of the aging Multi-Satellite Operations Control Center. The SAMPEX, Goddard's most recent launch, is the first spacecraft to be controlled using the new Transportable Payload Operations Control Center (TPOCC) architecture. Future spacecraft POCCs are being implemented in the TPOCC architecture with distributed workstations to take advantage of the increased processing capability and lower cost. Other related mission systems include the Johnson Space Center/Goddard Space Flight Center Shuttle POCC Interface Facility (SPIF) and the Mission Planning/Command Management System to generate command sequences for transmission by the POCCs to the spacecraft, and the User Planning System (UPS) to schedule spacecraft communications periods through the Tracking and Data Relay Satellite System (TDRSS).

The Mission Operations program provides for the operation of the mission control centers and the related software and services necessary for the monitoring and control of in-orbit spacecraft and prelaunch preparations for new spacecraft.

Control facilities for spacecraft and payload operations have the capability for receiving, processing, and displaying spacecraft engineering data and for generating commands. Commands are generated in response to emergencies and also preplanned in sequences and transmitted to the spacecraft to carry out the mission objectives. Software is developed for the control of each new spacecraft, made up of approximately 50% reused standard software and 50% mission-unique software. Each facility is operated 24 hours per day, 7 days per week for mission services. For Shuttle missions with attached payloads operated by GSFC, a specialized system processes and displays Shuttle-unique data that is needed for payload control.

The Data Processing Systems Implementation program provides for the procurement of equipment and development of data processing and computational systems at GSFC that are required by a broad range of Earth orbiting scientific missions. These systems determine spacecraft attitude and orbits, and generate attitude and

orbit maneuvers for operating spacecraft. These systems also process the large volume of data produced by the operational spacecraft as a prerequisite to analysis of the data by the individual mission research projects.

Major data processing computational capabilities include the multimission Flight Dynamics Facility (FDF), which performs the real-time attitude, orbit and flight maneuver control computations. In FY 1993, the FDF computers were replaced with faster computer systems under a lease/purchase contract. In addition, migration of the FDF from mainframe computers to a future distributed computing architecture will allow for increased capacity and minimized life-cycle expenses. Other activities within this program include the development and test of advanced data system components. Through these facilities, advanced techniques in the areas of remote payload operation and control, expert systems, high-speed data processing, high-level languages, and custom-engineered hardware processors using Very Large Scale Integration (VLSI) will continue to be applied to operational systems to replace costly conventional systems and to reduce operational staffing needs.

The Data Processing Systems Implementation program funds four major systems for processing spacecraft data: (1) the Packet Data Processor (PACOR), which processes data from satellites that employ the new packet technology and protocols; (2) the Hubble Space Telescope (HST) Data Capture Facility (HSTDCF), which captures, processes, and forwards the packetized telemetry from the HST to the Science Institute Facility; (3) the Generic Time Division Multiplexer (GTDM) Facility, which processes data from all Time Division Multiplexer (TDM) satellites; and (4) the Spacelab Data Processing Facility (SLDPF), which performs the data processing required by Spacelab missions. As noted, in FY 1995 the GTDM will be terminated and the SLDPF will be transferred from GSFC to the Marshall Space Flight Center (MSFC).

The large number of missions using modern packet data systems require corresponding packet data processing services. These missions include the SMEX series, SOHO, Cluster, and others. The existing packet data processing system is being expanded to provide the required increased data processing capability in a cost-effective way, by taking advantage of advances in distributed computing and VLSI digital processing.

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a usable form prior to analysis by the scientific investigation teams. Data are processed to separate spacecraft telemetry from the scientific data gathered by on-board instruments and systems. This data must be consolidated and marked with key spacecraft telemetry and temporal information. This transformation is performed as part of the data processing function and is funded under the Data Processing Operations program. Use of this capability extends across a variety of NASA missions, ranging from the small explorer satellites to more complex imaging satellites.

The Data Processing Operations program funds the management, maintenance and operation of the data processing and flight dynamics facilities at the GSFC. The FDF provides attitude and orbit products and

services for the NASA low Earth-orbital spacecraft in all mission phases. Flight Dynamic software is developed and operated throughout the life of the missions.

BASIS OF FY 1995 ESTIMATE

The FY 1995 budget request for Mission Control Systems Implementation includes funds for continued development of mission control capabilities at the GSFC for the SMEX missions and of replacement equipment for the HST control center. Funds are also needed to procure equipment to implement control center facilities for the upcoming Tropical Rainfall Measurement Mission (TRMM), SOHO, X-ray Timing Explorer (XTE), Advanced Composition Explorer (ACE), and TOMS missions.

The Mission Control Operations program includes funds for the operation of control centers and facilities for control of ten missions which will be fully operational throughout the year, and for the three new missions scheduled to be launched in FY 1994. Additional funds are used to develop the control center capabilities needed for spacecraft under construction that will be launched beyond 1994. The funds will also be used to provide a scheduling system to be used with the new Danzante facility (formerly called the Second TDRSS Ground Terminal). These enhancements are required to permit the control centers to operate with evolving NASA ground systems, to control the increased number of spacecraft, and to accommodate the higher data rates and complexity of new spacecraft. Previously planned improvements to the planning, scheduling, and command generation system for the HST have been deleted due to budget constraints.

The Data Processing Systems Implementation program request reflects cost savings to be achieved by consolidating the Spacelab Data Processing Facility functions with the control center functions. The request also reflects discontinuing the operation of the Generic Time Division Multiplex (GTDM) data processing facility, consistent with Agency plans to standardize on packet data systems. The budget request includes funds to meet future packet processing requirements of SOHO and other missions under development. As noted, in FY 1995 the GTDM will be terminated and SLDRF functions will be transferred from GSFC to MSFC. Funds are also requested for upgrading the capability to exchange data within the data processing complex and to other mission service facilities.

The budget request includes funding for equipment to provide the required reliability and availability of the FDF consistent with commitments to ongoing missions, new mission initiatives, and internal services to the space and ground networks, along with the acquisition of some elements of the future distributed architecture systems. The budget request also includes funding for the Data Systems Technology program to maintain the VLSI capability developed over several years and to apply state-of-the-art technologies to prototype and operational systems for mission control, data processing, and communications.

Significant reductions to the Data Processing Operations program will occur due to the consolidation of the SLDPF functions and the phase out of GTDM data processing. The FY 1995 budget request will provide for the

continued operation of the general packet data processing system and the Hubble Space Telescope Data Capture Facility. The budget request also reflects termination of attitude and orbit services to the COBE spacecraft and reduced flight dynamics services for the upcoming TOMS, XTE, TRMM, WIND, POLAR, SOHO, and ACE projects in the areas of mission analysis and health and safety monitoring of the spacecraft attitude control systems.

BASIS OF FY 1995 FUNDING REQUIREMENT

SPACE NETWORK CUSTOMER SERVICES

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Space network customer services.................	27,900	30,000	32,000

OBJECTIVES AND STATUS

The Space Network Customer Services program provides access to the multimission communications network serving all TDRS-compatible Earth orbiting missions. The program provides for the operation and maintenance and improvement of the those ground systems and facilities located at the Goddard Space Flight Center (GSFC), including the Network Control Center (NCC), required to schedule user services and to control and operate the Space Network system.

Beginning in FY 1995, funding previously provided under the Space Network Operations and Systems Engineering and Support programs are now combined. Capabilities that represent the services needed to provide user access to the Space Network, representing both scientific and other purposes, have been combined in the Space Network Customer Services program under the Science, Aeronautics and Technology appropriation.

The objective of this program is to develop and maintain the interfaces required by users for the Space Network. In order to serve its many users, customer service provides user scheduling, ground equipment configuration, and fault isolation services for the network. In addition, mission planning, user communications systems compatibility, simulation, and testing services are provided to the network and flight project to insure network readiness and technical compatibility for in-flight communications. Also funded under this program element is the NCC at the GSFC which provides customer interface to the Space Network system.

Finally, engineering services, hardware and software development required to sustain and improve the Space Network are funded by this program. Equipment design and replacement; logistics support; and specialized maintenance, configuration management, and procedure development are provided under the Space Network Customer Services program. These services are critical to insuring reliable space communication and network operation in support of user spacecraft systems.

BASIS OF FY 1995 ESTIMATE

Funds are requested for operations, hardware and software maintenance, sustaining equipment purchases, and software modifications for the Network Control Center, Simulations Operations Center, Compatibility Test Vans, and related analytical tools and support systems. Related engineering, documentation, mission and operational analytical services are also provided under this program.

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BASIS OF FY 1995 FUNDING REQUIREMENT

ADVANCED TECHNOLOGY

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Advanced technology	23,273	24,600	--

OBJECTIVES AND STATUS

The objective of the Advanced Technology program is to improve the performance, capability and reliability of future space missions in the critical areas of communications, navigation, and mission operations. This is accomplished in the program by evaluating and developing new technologies to demonstrate their feasibility to a level that allows field implementation to be undertaken with confidence. The research and development under this program has, over the years, enabled the cost-effective introduction of new technology and techniques into the Deep Space Network, the Space Network, communications systems, and data processing systems.

BASIS OF FY 1995 ESTIMATE

Beginning in FY 1995, the Office of Space Communications' Advanced Systems program will no longer be funded as a separate element. Essential activities will be reconstituted within the Mission Communication Services program.

BASIS OF FY 1995 FUNDING REQUIREMENT

CONSTRUCTION OF FACILITIES

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Construction of facilities.....................	31,800	17,600	--

OBJECTIVES AND STATUS

The FY 1993 funding provided for the construction of two 34-meter high efficiency beam wave guide (BWG) type multifrequency antennas at the Goldstone Deep Space Communications Complex. The FY 1994 funding provides for an additional antenna 34-meter BWG antenna at the Canberra, Australia Deep Space Communications Complex. These new antennas will provide performance improvements for mission support.

BASIS OF FY 1995 ESTIMATE

No Construction of Facilities funds are requested in FY 1995.

SCIENCE, AERONATUICS AND TECHNOLOGY

FISCAL YEAR 1995 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1993	FY 1994	FY 1995	Page Number
		(Thousands of dollars)		
Education	70,200	54,300	56,300	SAT 8.1
Minority university research and education	22,700	31,200	40,900	SAT 8.2
Total	92,900	85,500	97,200	

BUDGET SUMMARY

ACADEMIC PROGRAMS

EDUCATION PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1993	FY 1994	FY 1995	Page Number
		(Thousands of dollars)		
Student programs	9,800	10,700	11,200	SAT 8.1-4
Teacher/faculty	11,120	12,000	14,300	SAT 8.1-6
Comprehensive	25,680	26,500	26,400	SAT 8.1-8
Education technology	4,200	5,100	3,900	SAT 8.1-11
Special projects	19,400	--	--	
Evaluation	--	--	500	SAT 8.1-12
Total	70,200	54,300	56,300	
Distribution of Program Amount by Installation				
Johnson Space Center	1,253	1,175	1,198	
Kennedy Space Center	1,280	1,349	1,375	
Marshall Space Flight Center	1,397	1,392	1,491	
Stennis Space Center	1,505	1,509	1,539	
Langley Research Center	1,250	1,285	1,310	
Lewis Research Center	1,365	1,413	1,441	
Ames Research Center	1,355	1,519	1,549	
Goddard Space Flight Center	1,270	1,392	1,419	
Jet Propulsion Laboratory	1,525	1,601	1,633	
Headquarters	58,000	41,665	43,345	
Total	70,200	54,300	56,300	

ACADEMIC PROGRAMS | EDUCATION PROGRAM

OBJECTIVES AND JUSTIFICATION

The goal of NASA's Education program is to promote excellence in America's education system through enhancing and expanding scientific and technological competence. This program directly supports three of the National Goals for Education, including goal number four that states by the year 2000, U.S. students will be the first in the world in mathematics and science achievement. NASA's program is designed to capture and channel student interest in science, engineering, mathematics, and technology, as well as enhance teacher and faculty knowledge and skills related to these subjects. These Agencywide pre-college, university and minority university programs are in support of NASA's education mission to ensure a sufficient talent pool to preserve NASA and U.S. leadership in aeronautics, space, Earth science, and technology and to help meet the national education goals.

The specific objectives of the Education program are:

- To disseminate to the pre-college educational community -- students, teachers, and administrators -- experience and knowledge derived from NASA research and development and its application to the study of mathematics, science, and technology;

- To encourage elementary and secondary students to take greater interest in mathematics, science, and technology through the use of advanced instructional technology, development of strong teacher resource centers, curriculum materials designed for the elementary level, and the initiation of cooperative relationships with private industry, local school systems, and community organizations;

- To significantly increase the number of highly trained scientists and engineers in aeronautics, space science, space applications, and space technology to meet the continuing needs of the national aerospace effort;

- To facilitate the direct interaction, further the professional knowledge and stimulate the exchange of ideas between university faculty members and NASA scientists and engineers;

- To explore the application of state-of-the-art technologies to enhance teaching methods and improve dissemination of education program materials;

- To support innovative research at U.S. institutions of higher learning that is in the formative or embryonic stage and that would appear to have significant potential to advance space science and applications programs; and

- To provide for the development and use of a core, long-term U.S. national university capability to conduct multiyear, Earth science discipline-oriented applied research and remote sensing.

NASA is actively involved in the activities of the National Science and Technology Council/Committee on Education and Training (NSTC/CET). This budget request supports programs which contribute to the program domains as defined by the Committee on Education and Training (CET), and is supportive of the milestones outlined in the CET Strategic plan.

Beginning in FY 1994, the Academic programs budget has been restructured to more clearly reflect the educational focus of the programs and to be consistent with the CET activities. There has been no change to the individual programs that have comprised the NASA Education program. For budget purposes, these programs have been grouped to reflect the educational emphasis or the audiences the programs seek to reach.

BASIS OF FY 1995 FUNDING REQUIREMENT

STUDENT PROGRAMS

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Elementary and secondary	2,800	3,100	3,700
Higher education	7,000	7,600	7,500
Total	9,800	10,700	11,200

OBJECTIVES AND STATUS

The Student programs at the Elementary and Secondary level include a series of programs to capture student interest in mathematics, science and technology, and channel that interest into mathematics, science and technology career paths. By demonstrating the applications of mathematics, science and technology in aeronautics and space, programs such as the Summer High School Apprenticeship Research Program (SHARP), SHARP-PLUS, Space Science Student Involvement Program (SSIP), and the Shuttle Amateur Radio Experiment (SAREX) program encourage students to become interested in and pursue coursework in these fields of study. NASA's involvement in science and engineering fairs and cooperative activities with other agencies and organizations continue to stimulate interest in aeronautics and space sciences among middle and secondary school students.

At the Higher Education level, the Graduate Student Researchers Program (GSRP), initiated in 1980, provides graduate fellowships nationwide to post-baccalaureate U.S. citizens to conduct thesis research at a NASA Center or to carry out a program of study or research at their home institution. Awards are made to graduate students for a maximum of three years. On an annual basis, NASA supports approximately 500 graduate students pursuing the masters or doctorate degrees in science, engineering, mathematics, and technology.

BASIS OF FY 1995 ESTIMATE

The FY 1995 funding will allow for the continuation of NASA student involvement programs (SHARP, SHARP-PLUS, SSIP, and SAREX). To enhance the current SHARP program, which now targets approximately 200 underrepresented minority students at the 11th and 12th grade level, the program has been extended to a nationwide SHARP-PLUS program that will involve upwards of 1,000 students by the time it is fully implemented in 1996. The SSIP is being expanded to include fourteen competition activities, encompassing

all 50 states, Puerto Rico and the District of Columbia throughout eight geographical regions. Program participation will expand from 100,000 students to 300,000 in FY 1995.

The FY 1995 request for Higher Education will maintain the fellowships at the graduate level. This program continues to be a very competitive program, with a 6 to 1 ratio of applications to awards.

BASIS OF FY 1995 FUNDING REQUIREMENT

TEACHER/FACULTY PROGRAMS

	FY 1993	FY 1994	FY 1995
	(Thousands of dollars)		
Elementary and secondary	1,720	2,200	4,600
Higher education	9,400	9,800	9,700
Total	11,120	12,000	14,300

OBJECTIVES AND STATUS

One of the priorities identified in the Committee on Education and Training's Strategic Plan is the immediate upgrading of the existing teaching workforce. The Teacher/Faculty programs at the Elementary and Secondary level include a series of teacher enhancement programs targeted at pre-college teachers. The goal is to enhance and improve the teaching of mathematics, science, and technology at the elementary and secondary level by demonstrating the application of mathematics, science and technology in aeronautics and space. Programs include: NASA Education Workshops for Elementary School Teachers (NEWEST), NASA Education Workshops for Math and Science Teachers (NEWMAST), Teaching From Space, Urban Community Enrichment Program (UCEP), Summer Teacher Workshops and Teacher Enhancement Workshops.

The Teacher/Faculty programs at the Higher Education level include programs created for graduate and undergraduate faculty to further their professional knowledge of engineering and science disciplines. Research opportunities for undergraduate and graduate faculty are provided through access to the NASA laboratories and to our extensive datasets. The Summer Faculty Fellowship Program (SFFP) provides highly beneficial opportunities for engineering and science faculty throughout the U.S. to participate in NASA research. This program has contributed significantly to the improvement of both undergraduate and graduate education, and directly benefits NASA, universities, faculty, students, and the Nation. Approximately 300 university faculty are supported annually for ten weeks. Evaluations conducted by the American Society for Engineering Education (ASEE) of the program indicate that approximately 30-40% of the participating faculty subsequently receive NASA research grants or contracts.

The JOint VEnture (JOVE) and Innovative Research programs also provide opportunities for undergraduate faculty to come to the NASA Centers to work with NASA data and to enhance research and teaching capabilities. The JOVE is managed by the Marshall Space Flight Center, where it was initiated as a pilot program in 1989. NASA provides scientific on-line data from space missions, as well as support for

electronic work stations and partial faculty and student support. In turn, the universities agree to grant faculty release time, student support, and an instructional unit on a space science topic. There are currently 75 academic institutions in 44 states and Puerto Rico participating. This program allows NASA to provide data to a broader range of academic institutions.

The Innovative Research program is managed through the Offices of Space Science and Mission to Planet Earth, to support research which has the potential for significant advances for Planetary and Earth Science and Astrophysics. This program is intended to provide a mechanism for the funding of scientifically sound proposals which might not be funded through normal channels either because of their interdisciplinary nature or because they are speculative or risky. The long-term goal is to help the new ideas mature to a state of acceptability within a particular science discipline.

BASIS OF FY 1995 ESTIMATE

The FY 1995 funding will allow for expansion of NASA sponsored teacher workshops (NEWEST/NEWMAST) and increased participation in a National Science and Technology Council/Committee on Education and Training (NSTC/CET) program for long-term teacher enhancement activities. In 1993, NASA participated in a NSTC/CET pilot program for long-term teacher enhancement where teachers were given a month of in-service and work related opportunities at the Marshall Space Flight Center and the Jet Propulsion Laboratory. The cost is approximately $5,000 per teacher. NASA will increase the number of participating teachers in FY 1995 to approximately 500. This represents an increase of 350 teachers over FY 1994. In addition, NEWEST/NEWMAST will support an additional 50 teachers this year for a total of approximately 260 teachers.

The FY 1995 funding for Higher Education will provide for continuation of ongoing projects and a limited number of new awards.

BASIS OF FY 1995 FUNDING REQUIREMENT

COMPREHENSIVE

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Aerospace education services program (AESP).....	6,500	6,300	6,300
Space grant college and fellowships.............	13,400	14,500	14,400
Experimental program to stimulate competitive research (EPSCoR)............................	5,000	5,000	5,000
Tri-state education initiative program..........	780	700	700
Total....................................	25,680	26,500	26,400

OBJECTIVES AND STATUS

These programs address many different levels within the education community and include: the Aerospace Education Services Program (AESP), Space Grant College and Fellowships Program, Experimental Program to Stimulate Competitive Research (EPSCoR), and the Tri-State Education Initiative Program.

The AESP, also known as Spacemobile, is NASA's premier outreach program at the elementary and secondary education level. The AESP specialists, all former science, mathematics, or technology teachers, capture the interest of millions of students and enhance the teaching skills of teachers each year by using aeronautics and space as a catalyst in the teaching of science, mathematics, and technology. The AESP specialists visit schools throughout the U.S., conducting student assemblies and teacher workshops. The AESP specialists also conduct teacher workshops at the NASA Centers and various colleges and universities. The format of the AESP is being redesigned. New training and program delivery strategies are being implemented to include more teacher enhancement emphasis and support of the National Science Foundation systemic change initiatives.

The Space Grant College and Fellowships program is composed of three interrelated elements: Designated Space Grant Colleges/Consortia, Space Grant Program Consortia, and Space Grant Capability Enhancement Consortia. The 21 Designated Space Grant Consortia were selected in 1989 and are led by preeminent institutions which are substantially involved in a broad spectrum of NASA research, offer advanced study in aerospace fields, and are significantly involved in related public service. In FY 1992, 1993, and 1994, designated schools received grants ranging from $295,000-$380,000.

In FY 1991, a second competition took place to select states for Program Grants or for Capability Enhancement Grants (the difference between the two types of programs is related to current involvement in aerospace fields). Twenty-nine proposals were received. Of those 29, fourteen were funded as Program Grants, twelve as Capability Enhancement Grants and three as planning grants. Selections were announced in February 1991. Program Grant and Capability Grant awardees received $150,000 in FY 1991, a portion of which was to be used for fellowships. In FY 1992, FY 1993, and FY 1994, the states received an additional augmentation of $20,000, with the opportunity to receive an additional $35,000, depending upon the size of the consortium. The three states which received planning grants of $25,000 each, were brought into the program as fully-funded Capability Enhancement grantees, along with Vermont and Puerto Rico, in FY 1992. Institutions of higher education involved in the Space Grant program currently number over 400. All consortia match their grants at 100% in either dollars and/or cost sharing arrangements to carry out programs of education, public service, and research.

The FY 1993 NASA Authorization Act (P.L. 102-588) directed NASA to initiate a program to strengthen the research capability of states that do not successfully participate in competitive space and aeronautical research activities. This program, modeled after the National Science Foundation's Experimental Program to Stimulate Competitive Research (EPSCoR), provides seed funding that will enable eligible states to develop an academic research enterprise directed toward long-term, self-sustaining, nationally competitive capability in space science and applications, aeronautical research and technology, and space research and technology programs. This capability will, in turn, contribute to the state's economic viability.

A program announcement was issued in June 1993 advising eligible states of the opportunity to submit proposals for the NASA EPSCoR program. Nineteen proposals were received, and after a thorough, merit-based review, up to nine awards will be made in early 1994. As the selected states are also part of the Space Grant College program, the two programs are being closely coordinated.

The goal of NASA's Tri-State Education Initiative program is to provide educational programs, as requested by the educators of the Tennessee/Alabama/Mississippi region in a manner consistent with NASA's total education program, and to support systemic reform of the education system as recommended in the Goals 2000 education program. Originally, the Tri-State Education Initiative was to provide needed education programs to an underserved area affected by the Advanced Solid Rocket Motor (ASRM). However, it became clear in the early planning phase of the program that since major education reforms were the results desired by the education personnel in the region, a more comprehensive and long-term program was required. The region is an excellent location for a program aligned with the national education goals and the Goals 2000 plan, and therefore, it was determined that the education program should be carried forward independently of the termination of the ASRM program. NASA's principal role has been as a facilitator in order to (a) identify the education-related needs of schools in the Tri-State area, (b) convene representatives of other Federal agencies (e.g. Departments of Energy and Education, Tennessee Valley Authority) in order to guide support of Federal resources to the area, and (c) provide direct education services where appropriate.

BASIS OF FY 1995 ESTIMATE

The FY 1995 funding request for AESP will allow for continuation of the current program, with funding targeted toward maintaining the staffing level of specialists and upgrading aerospace models and vans. Activities for FY 1995 include development of instruction media, program evaluation activities, and expansion of the Urban Community Education program to reach additional inner city communities.

The FY 1995 funding request for the Space Grant College and Fellowships program will continue funding to all 51 consortia. Funds will also be used to perform program evaluation activities, which include site visits to Space Grant college campuses, and to initiate community college and undergraduate teaching initiatives. A Space Grant Review Panel will be convened, as directed by Congress in House Report 103-150 and Senate Report 103-137.

Implementation of the NASA EPSCoR program will continue in FY 1995, through renewal of grants awarded in FY 1994. Progress of the participating states will be evaluated in FY 1996; the results of that evaluation will determine whether states may qualify for an additional two year award.

The FY 1995 funding will provide for continuation of the Tri-state Education Initiative.

BASIS OF FY 1995 FUNDING REQUIREMENT

EDUCATION TECHNOLOGY

	FY 1993	FY 1994	FY 1995
	(Thousands of dollars)		
Education technology..........................	4,200	5,100	3,900

OBJECTIVES AND STATUS

NASA's Education Technology effort is an essential component of the Agency's Education program. Education technology products and services produced will ensure that NASA is able to develop a high level of leadership in Education technology as it has in aeronautics and space technology. Education technology is one of NASA's highest priorities for FY 1994 and beyond. Fundamental work is underway to make available, in a user friendly format, the results of NASA's research (e.g., data sets) to the education community; and to translate NASA's research tools into education formats (e.g., virtual reality). Significant education technology products have been produced or are under development, and a research and development center for education technology, the Classroom of the Future, is under construction.

BASIS OF FY 1995 ESTIMATE

The FY 1995 funding reflects a real increase of $800,000, and will allow for the development of several technology-based products of high priority to NASA. These include a videodisk for Earth systems science, a feasibility study of a telecourse for teachers, and enhancements to the Spacelink Computer Information System. Funding will be used for NASA Select educational video programming, expansion of the Regional Teacher Resource Center Network, hands-on participatory science using computers and telecommunication systems, and the Classroom of the Future. As was addressed in an earlier section discussing changes between the FY 1994 Amended Budget Request and the FY 1994 Current Estimate, the Congress directed a $3.0 million increase in funding for Educational Technologies in FY 1994. The projects to be funded by this increase are being defined.

BASIS OF FY 1995 FUNDING REQUIREMENT

EVALUATION

	FY 1993	FY 1994	FY 1995
	(Thousands of dollars)		
Evaluation....................................	--	--	500

OBJECTIVES AND STATUS

Evaluation is essential to the effectiveness of the NASA Education program. Therefore, a comprehensive evaluation plan has been drafted and is being implemented to ensure that necessary data are gathered to provide for accountability in the use of Federal funds, monitor progress, provide feedback, and document program outcomes. The evaluation plan includes both short- and long-term actions.

In the short-term, the following actions have been or will be conducted: (1) The Education Division conducted a major Agencywide survey in FY 1992 to identify all existing NASA Education programs. This database will be maintained and the survey will be repeated every three years; (2) A data collection and management system has been designed and implementation is underway for all national education programs. Implementation will be completed by FY 1994; and (3) NASA is participating in National Science and Technology Council/Committee on Education and Training (NSTC/CET) activities designed to improve and coordinate evaluations of Federal education programs and develop evaluation standards.

Two major long-term efforts are underway. First, the National Research Council (NRC) is conducting a study to identify evaluation indicators for all of NASA's Education programs. These indicators will become standards against which programs will be evaluated for termination, modification, or enhancement. Second, NASA's data management system will be expanded to all Field Centers to provide a database system of evaluation data. Additionally, the database will be modified to be consistent with the recommendations resulting from the NRC study and with the NSTC/CET evaluation standards.

BASIS OF FY 1995 ESTIMATE

The funding for FY 1995 will initiate an external comprehensive evaluation of NASA's education programs.

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1995 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS

MINORITY UNIVERSITY RESEARCH AND EDUCATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1993	FY 1994	FY 1995	Page Number
		(Thousands of dollars)		
Historically black colleges and universities....	11,400	17,700	17,800	SAT 8.2-4
Other minority universities....................	4,800	7,000	16,600	SAT 8.2-6
Graduate student researchers program/ Underrepresented minority focus	3,400	3,400	3,400	SAT 8.2-9
Undergraduate student researchers program/ Underrepresented minority focus	3,100	3,100	3,100	SAT 8.2-10
Total..................................	22,700	31,200	40,900	

Distribution of Program Amount by Installation

	FY 1993	FY 1994	FY 1995
Johnson Space Center..........................	350	1,654	2,438
Kennedy Space Center..........................	400	527	777
Marshall Space Flight Center..................	1,125	1,488	2,194
Stennis Space Center..........................	150	200	294
Langley Research Center.......................	1,506	1,991	2,935
Lewis Research Center.........................	894	1,182	1,744
Ames Research Center..........................	150	200	294
Goddard Space Flight Center...................	1,383	1,828	2,696
Jet Propulsion Laboratory.....................	1,290	1,707	2,516
Headquarters..................................	15,452	20,423	25,012
Total..................................	22,700	31,200	40,900

ACADEMIC PROGRAMS

MINORITY UNIVERSITY RESEARCH AND EDUCATION PROGRAM

OBJECTIVES AND JUSTIFICATION

NASA has made a major commitment to being a leader in strengthening the research infrastructure capabilities of minority universities to compete for "mainstream" federal research funding. The Congress and Executive Branch have established a clear record of commitment to increasing the involvement of minority institutions in federally sponsored programs. One of the President's national education goals, and a milestone in the National Science and Technology Council/Committee on Education Strategic Plan is to increase the number of women and minority students receiving graduate and undergraduate degrees in mathematics and science. NASA, through the Office of Equal Opportunity Programs (OEOP), seeks to bring together a strong research focus and alliances between minority institutions, majority research universities, state and local governments, elementary and secondary schools, industry and other Federal research and development (R&D) agencies to encourage the development of a resource pool of talent. The OEOP pursues this alliance through the aggressive implementation of initiatives for Historically Black Colleges and Universities (HBCUs), by developing closer relationships with Other Minority Universities (OMUs) including Hispanic Serving Institutions (HSIs), and by continuing the student scholarship and fellowship programs at the Graduate and Undergraduate levels. In support of the National Education Goals, NASA will increase opportunities for teacher preparation and enhancement at the elementary and secondary level in schools with significant minority enrollments.

The goals of the NASA minority university research and education programs are to improve and expand the research capability of selected HBCUs and OMUs, and to encourage the development of a resource pool of talent through a strong research focus. One of the objectives of the President's goal in mathematics and science education is to increase the number of women and minority graduate and undergraduate students receiving degrees in mathematics, science and engineering. NASA endeavors to achieve this goal through the aggressive implementation of initiatives for HBCUs; by developing closer relationships with OMUs; and by continuing the Graduate Student Researchers program, Underrepresented Minority Focus (GSRP/UMF); and, the Undergraduate Student Researchers programs, Underrepresented Minority Focus (USRP/UMF). An additional responsibility for NASA and the OEOP's Minority University Research and Education Division (MURED) will be to ensure that opportunities for K-12 teachers and students at elementary and secondary schools with significant minority enrollments are enhanced under Executive Order 12821, entitled "Improving Mathematics and Science Education in Support of the National Educational Goals."

NASA's HBCU initiative is mandated by Executive Order 12876, which requires Federal agencies to increase significantly the involvement of HBCUs in Federally sponsored programs. Congress also mandated NASA, in FY 1985, to build closer relationships with universities that tend not to be major research institutions, but do have significant minority enrollments. To accomplish this goal, the Agency has established the OMU program to focus on meeting NASA's research objectives, and concurrently, increase the number of individuals from underrepresented groups in the pool of graduate researchers while not diminishing the Agency's effort toward HBCUs. Additionally, under the auspices of the OMU program, NASA is responsive to Executive Order 12729 on Educational Excellence for Hispanic Americans which directs Federal agencies to be actively involved in helping advance educational opportunities for Hispanic Americans. As directed by the FY 1994 House Appropriation Committee Report, NASA has adopted the definition of HSIs under Part A of Title III of the Higher Education Act, which also establishes HSIs as worthy of special Federal attention.

NASA implements both the HBCU and OMU programs' initiatives primarily using research and training grants sponsored through the MURED in the OEOP. The research and training grants focus on specific research disciplines relevant to NASA requirements in science and technology and are used to support faculty and students at HBCUs and OMUs, thereby increasing the scientific and technological contributions from these institutions and increasing the pool of minorities in NASA-related science and engineering disciplines. In FY 1992, the NASA Institutional Program Offices (IPOs) became directly involved and responsible for the selection, funding, and conduct of minority university research. Currently, the IPOs and other technically oriented program offices are working collaboratively with the OEOP to expand institutional research capability at minority universities and to enhance research opportunities for faculty principal investigators (PIs) and student researchers in their program offices' areas of responsibilities. Ultimately, it is anticipated that the institutions, faculty and students will compete successfully in NASA's mainstream research and employment processes. This new process also facilitates NASA's efforts to comply with Congressional mandate to expand HBCU research centers and develop mechanisms for increased participation by faculty and students of HSIs in mainstream research.

To encourage the development of talent at the undergraduate and graduate level, NASA will continue the GSRP/UMF, the USRP/UMF, and expand the undergraduate scholars programs at HBCUs and OMUs, including HSIs. NASA's efforts in these areas were highlighted when Congress noted that "the agency's goal of expanding opportunities for capable students from underrepresented groups pursuing degrees in engineering and science disciplines is not only deserving but clearly in our nation's self interest."

BASIS OF FY 1995 FUNDING REQUIREMENT

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Historically black colleges and universities....	11,400	17,700	17,800

OBJECTIVES AND STATUS

The objectives of the Historically Black Colleges and Universities (HBCU) program are to continue to increase the level of NASA's participation with HBCU's and to strengthen the infrastructure of selected universities. Congress directed a major increase in the HBCU program in FY 1994. Despite the overall Agency budget constraints, the increased level of funding will be maintained in FY 1995. This reflects NASA's commitment to play a leadership role in strengthening the research capabilities of the Nation's minority research institutions, and to increasing the pipeline of minority scientists and engineers into the workforce. Special emphasis will be placed on enhancing the mathematics and science abilities of students at these universities, which will lead to careers in science and engineering research and education. The NASA Program Offices and Field Centers play an integral role in the HBCU program. All research efforts are coordinated through the NASA technical offices and are responsive to NASA research needs. These program offices contribute research funds to the HBCU research programs, ensuring a coordinated approach between the Office of Equal Opportunity Programs (OEOP) and the NASA technical programs. The Program Offices involved in the OEOP programs include the Office of Space Science, the Office of Mission to Planet Earth, the Office of Life and Microgravity Sciences, the Office of Advanced Concepts and Technology, and the Office of Space Flight.

In FY 1991, seven HBCUs were selected through a competitive process to be HBCU Research Centers. This competition was based on the strength of these institutions in science and technology disciplines related to NASA research requirements. The goal of this program is to strengthen the capability of these institutions to compete effectively against other "mainstream" research institutions for NASA funding. The HBCU Research Centers received initial funding in FY 1992, and regularly meet with the NASA Centers and Headquarters Program Offices, to implement focused research activities leading to "mainstream" capability at the HBCU's. Research Center activities involve Principal Investigators (PIs) and graduate and undergraduate students. Collaborative efforts between the Equal Opportunity Programs Office and the NASA Program Offices will provide funding, technical assistance and long term guidance for the HBCU Research Centers.

The HBCU Institutional Research Awards (IRA) program is designed to strengthen the capacity of HBCUs, by building institutional infrastructure and providing a quality learning and research environment. Research awards awarded under this program provide a quality learning and research environment for underrepresented minorities to increase their opportunity to participate in Federal research activities.

The Mathematics, Science, and Technology Teacher Awards for Teacher and Curriculum Enhancement focuses on enhancing the teaching skills of secondary level teachers. This program, which will be initiated in FY 1995, seeks to: (1) increase the number of state certified underrepresented minority teachers in schools with substantial enrollments of minorities, by strengthening the technical skills and knowledge of underrepresented middle and secondary science, mathematics and technology pre-service teachers; and, (2) to improve science and mathematics literacy among underrepresented minority pre-service and in-service teachers and middle and secondary students. Five awards are planned for FY 1995.

Consistent with the Agency's FY 1991 commitment to issue a FY 1994 call for research proposals from underrepresented minority principal investigators at HBCUs, the Faculty Awards for Research (FAR) program was expanded for this purpose. Ten HBCU PIs were selected as FAR recipients and approximately ten additional HBCU PIs will be selected during FY 1995. The FAR was established under the Other Minority University (OMU) program to encourage outstanding and promising underrepresented minority faculty to propose research in NASA-related fields of space and Earth science and aerospace technology. Awards up to $75,000 are made for up to three years based on the annual determination of continuing achievement and subject to the availability of funds.

The Facility Enhancement and Faculty Development initiative, started in FY 1994, will be continued in FY 1995. This program seeks to increase outreach efforts to minority students at community colleges. The goals of this program are to: (1) improve the facilities; (2) enhance the mathematics and science curriculum; (3) upgrade the credentials of the mathematics and science instructors; and (4) improve the transfer rates of science, mathematics, and engineering students to four-year institutions.

BASIS OF FY 1995 ESTIMATE

In FY 1995, the seven HBCU Research Centers will be continued for the fourth of a five-year commitment by NASA. Funding for the HBCU Research Centers includes contributions from the NASA program offices for research conducted by the Research Centers, supplemented by funding from the OEOP.

In FY 1995, up to three new HBCU Institutional Research Awards will be competitively selected. The IRAs, which range from $400-$600 thousand each, are awarded to HBCUs other than the HBCU Research Centers.

Five Mathematics, Science, and Technology Teacher Awards for Teacher and Curriculum Enhancement are planned for FY 1995. These awards range from $150-$200 thousand each with an anticipated three year period of performance.

In FY 1995, the fourteen Faculty Awards for Research that were competitively awarded to individual PIs will be continued. In addition, fourteen new FAR awards will be competitively awarded. The FAR awards range from $50-$75 thousand each.

BASIS OF FY 1995 FUNDING REQUIREMENT

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Other minority universities....................	4,800	7,000	16,600

OBJECTIVES AND STATUS

The objectives of the Other Minority Universities (OMU) program are to continue to work in collaboration with NASA Program Offices and Field Centers to implement a comprehensive program that provides opportunities for universities with significant minority enrollments to compete for individual Principal Investigators (PI) awards, institutional research awards, and educational and training awards. These awards will enhance the retention and advancement of minority and disabled secondary students in mathematics-based curricula, expand science and mathematics enrichment opportunities for in-service teachers, and increase cultural diversity among pre-service mathematics and science teachers at schools with significant minority enrollments. NASA has made a major commitment to expanding this program. The Institutional Program Offices provide the majority of funding for NASA research conducted at OMUs, while the Office of Equal Opportunity Programs (OEOP) funds provide the majority of funding for the educational and training programs at these institutions. This collaboration ensures close coordination between the development of research capabilities at the OMUs and the research priorities of NASA.

In FY 1994, a program notice was issued to announce the Other Minority University (OMU) Research Center program, with awards to be made in FY 1995. This program will be patterned after the HBCU Research Center program and will target primarily Hispanic-serving institutions. The OMU Research Center program will be a collaborative effort with the Office of Space Science, the Office of Mission to Planet Earth, the Office of Aeronautics, the Office of Advanced Concepts and Technology, and the Office of Life and Microgravity Sciences and Applications in terms of the evaluation, selection and monitoring processes, and funding. The goal of this program is to establish university-broad based, competitive, core aerospace research capability among minority universities other than HBCUs. NASA seeks institutions which are committed to developing or enhancing a strong research base in one or more of the traditional space or Earth science and aerospace engineering disciplines or in a cross-discipline research. The objective is to foster new science and technology concepts, expand the nation's base for aerospace research and development, and develop mechanisms for increased participation by faculty and students at OMUs in mainstream research. NASA anticipates a five year commitment building up to $2,000,000 per year.

The Faculty Awards for Research (FAR) program described under the HBCU program was implemented and funded jointly between the NASA Program Offices and the OEOP as an outreach to principal investigators at OMU programs in FY 1992. Since that time, thirty outstanding and promising faculty researchers at OMUs have been competitively selected to conduct research in NASA related fields of space and Earth sciences, and aerospace technology. Each FAR recipient is assigned a technical monitor at a NASA installation or at the Jet Propulsion Laboratory.

The Institutional Research Award (IRA) for Minority Universities program was initiated in FY 1993. In FY 1994, six OMUs, including HSIs were selected for IRA awards. The IRA awards are designed to strengthen the capacity of minority universities by building institutional infrastructure and providing a quality learning and research environment for underrepresented minorities to increase their opportunity to participate in, and benefit from Federal programs. In FY 1995, funding for the six IRA institutions will be continued with a 20% increase in funding.

The Mathematics, Science, and Technology Teacher Awards for Teacher and Curriculum Enhancement Program (MASTAP), Underrepresented Minority Focus was initiated in FY 1994, and five awards are planned in FY 1995. The goals of this program are identical to the same program previously described under the HBCU program.

In FY 1994, a Native American Science and Technology Consortium (NASTEC) was established and funded. The guiding principles for NASTEC include respect for Native American cultural/tribal needs and the active participation of the Native American community, and capacity building and multicultural literacy. The goals of this program include addressing the special needs of the Native American community for technical literacy and skills development, and increasing the number of Native American scientists and engineers by the end of the decade.

The Facility Enhancement and Faculty Development initiative is expanded to include OMUs this fiscal year. The OMU program targets outreach to minority students at Tribal Colleges, other community colleges and liberal arts colleges with strong mathematics and science student transfers to four-year institutions. The goals of this initiative are: (1) to improve the facilities, (2) to expand the mathematics and science curriculum; upgrade the credentials of the mathematics and science instructors; and ultimately improve the transfer rates to four year institutions.

<u>BASIS OF FY 1995 ESTIMATE</u>

In FY 1995, funding for OMU programs is significantly increased to fulfill the commitment to ensuring cultural diversity in the NASA research community and outreach to Hispanic serving institutions. NASA will continue to fund comprehensive educational and training programs at OMUs, and the OEOP will work in close cooperation with the NASA technical program offices in funding NASA research efforts at these institutions.

In FY 1995, four to six OMU Research Centers will be competitively selected. Awards of $2 million per year, anticipated for five years, are planned. Funding for the FAR will continue the awards made in FY 1994, and provide for an additional ten new FAR awards in FY 1995. The FAR awards are approximately $75 thousand each. In FY 1995, the five Mathematics, Science, and Technology Teacher Awards for Teacher and Curriculum Enhancement Program (MASTAP) awards made in FY 1994 will be renewed. In FY 1995, two additional new awards will be made. The MASTAP grant awards are provided up to $200 thousand for each three years of support, for a total of up to $600,000. Funding for the Native American Science and Technology Consortium (NASTEC) is planned for $800 thousand. Funding is also included for OMU Facility Enhancement and Faculty Development awards for FY 1995.

BASIS OF FY 1995 FUNDING REQUIREMENT

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Graduate student researchers program/ underrepresented minority focus	3,400	3,400	3,400

OBJECTIVES AND STATUS

The objectives of the Graduate Student Researchers Program/Underrepresented minority focus (GSRP/UMF) are to enhance the development of underrepresented minorities and persons with disabilities in an effective way so as to utilize the potential of this Nation's diverse citizenry; and to increase the size of the resource pool of research skills that will be needed to meet aerospace and other technological objectives of the future. Graduate students who have research interests relevant to NASA's needs are competitively selected into the program. This program's targets are Blacks, Hispanics, American Indians, Pacific Islanders and the disabled. They must be enrolled in masters or doctoral programs in engineering, physics, mathematics, computer science, biology, or other disciplines of interest to NASA. Data show that approximately 76 of the GSRP/UMF students are in Ph.D. programs, and that Blacks and Hispanics make up about 93% of the program population. This is particularly encouraging since recent national scientific manpower data show Blacks and Hispanics making the least educational advancement of all target groups in science and engineering.

In FY 1993, the seventh year of the program, an additional 60 underrepresented minority students were selected for a total of 152 participants in the program. This total included 59 Black males, 25 black females, 46 Hispanic males, 12 Hispanic females, 3 American Indian males, 1 American Indian female, 1 Pacific Islander male and 3 Pacific Islander females and 2 disabled males. FY 1994 shows a continuing upward trend in applications and candidates. Candidates from Historically Black Colleges and Universities will be allowed to apply. (Previously they were excluded due to NASA's other programs for HBCUs).

BASIS OF FY 1995 ESTIMATE

Funding in FY 1995 will sustain the planned maximum operating level of 180 students.

BASIS OF FY 1995 FUNDING REQUIREMENT

	FY 1993	FY 1994	FY 1995
		(Thousands of dollars)	
Undergraduate student researchers program/ underrepresented minority focus...............	3,100	3,100	3,100

OBJECTIVES AND STATUS

This program, initiated in FY 1991, identifies high ability high school senior and continuing first year underrepresented minority and disabled students majoring in science or engineering and awards them portable scholarships through universities with proven records of recruiting, retaining and graduating minority science and engineering students. This program added approximately 75 students each year, so that by the fourth year (1994) NASA expects to be supporting approximately 300 students through the program. Our projected graduation rate is 85-90%, based on the fact that approximately 10% of the participants have dropped out of the program to date. The students receive tuition support; are monitored, tutored and nurtured; and spend their summers conducting research with principal investigators at their universities, NASA Installations, Federal laboratories or private industry. During their final year, students will be encouraged to apply for NASA's Cooperative Education program. The pipeline of undergraduate minority students majoring in the physical and life sciences and engineering coming from this program is expected to substantially and positively impact NASA's and the aerospace industry's hiring needs. Even more important, these students are being targeted for graduate level studies and research and teaching careers in the fields of science and engineering. The Undergraduate Student Researchers Program/ Underrepresented Minority Focus (USRP/UMF) may serve as a feeder to the Graduate Student Researchers Program/Underrepresented Minority Focus (GSRP/UMF).

In FY 1993, the third year of the program, an additional 71 underrepresented minority students were selected for a total of 211 participating in the program. This total included 107 African-Americans, 86 Hispanics, 9 Native Americans, 2 Pacific Islanders, and 7 students with disabilities. In FY 1994, the total participation will be increased to 300 students representing scientific and technical disciplines related to NASA's work force needs projected over the next ten years. The 300 student level represents the maximum student support possible under the anticipated funding levels through FY 1999.

BASIS OF FY 1995 ESTIMATE

The funding level of the USRP/UMF will approximate the funding level of the GSRP/UMF. Since the undergraduate component will serve as a feeder to the graduate component, the proposed budget structure for the undergraduate component represents a natural progression. NASA's goal is to have a continuous flow of

underrepresented minority undergraduate and graduate level students in science and engineering educational tracks related to the Agency's mission.